May 3, 1944

NATIONAL PETROLEUM NEWS

TECHNOLOGY DEPT.

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DETROIT

Official Navy Poster Celebrates "100 Octane Week" May 1 to 7 as a Tribute to the Oil Industry

REFINERY MANAGEMENT AND PETROLEUM CHEMICAL TECHNOLOGY EDITION—In 2 Sections, Section 1

Reminiscing

Back in '98 Morrison Bros. Co. was 43 years old. Those were the days of the "Walkin' Army", Mounted Cavalry, Mule Drawn Artillery and Coal Burning Navy. Today Morrison Bros. Co. is 88 years old, and many changes have taken place. Now every branch of the Armed Services depends on OIL in one form or another.

Oil Is Ammunition

Use It Wisely

On the Home Front, see that your tanks are protected with conservation vents that will reduce your evaporation losses to the minimum. Morrison Fig. 148 Conservation Vents and Fig. 312 Oil Seal Vents have proven themselves for this job.

Write for information.

BUY MORE

WAR BONDS

Fig. 148

Fig. 312

MORRISON BROS. COMPANY

OIL EQUIPMENT HEADQUARTERS

DUBUQUE, IOWA

LEARNING THE FOURTH 'R'

. . . REFININ'

Readin', Ritin' and Rithmetic are necessary, but not sufficient to operate our new Refining facilities, including the huge Republic "Cat Cracker" that will soon be in full production.

We're training a crew of both men and women to handle our biggest war job.

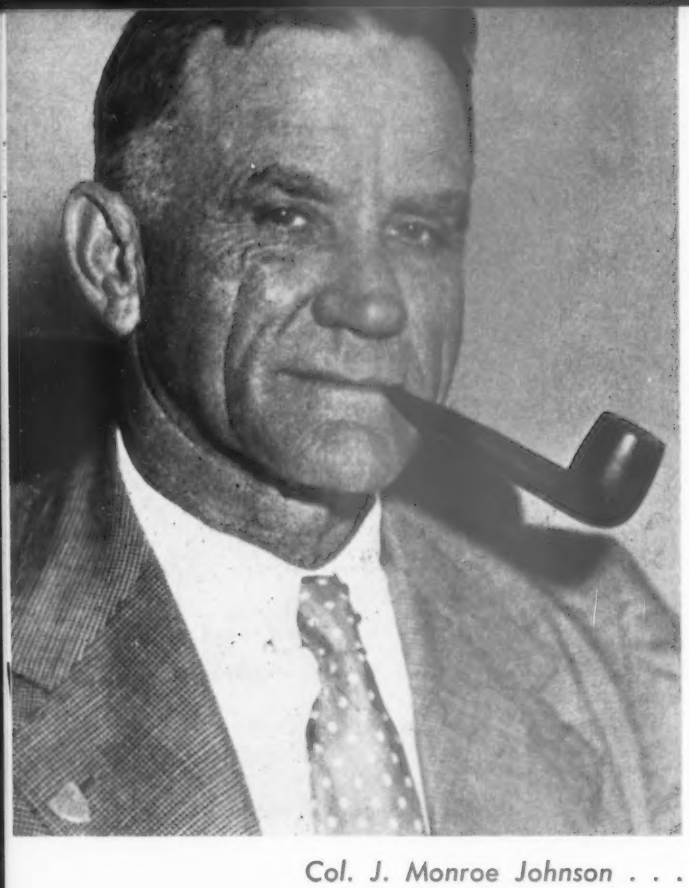
The new cracker will help to produce 100 Octane Gas, and its entire output will be used by the Government. But after the war our dealers and jobbers will benefit.

Plans are now being formulated which will result in heavy volume and more profit for our marketers. Wise business men are looking to Republic in the future, because . . .

REPUBLIC'S GOING PLACES

REPUBLIC OIL COMPANY

Benedum Trees Building **Pittsburgh, Penna.**



Col. J. Monroe Johnson . . .

Succeeds Eastman as ODT Chief

IN KEEPING the switches open for the movement of vital products of the petroleum industry, Col. J. Monroe Johnson, who was appointed director of the Office of Defense Transportation by President Roosevelt last month to succeed the late Joseph B. Eastman, has assumed one of the most important war roles on the home front. He is well equipped for his new post, both from the standpoint of experience and ability.

A civil engineer by trade, Col. Johnson is well-versed in interstate commerce, having served on this government commission since June, 1940, and has been in charge of the commission's bureau of service since shortly after his appointment. He will continue as a member of the commission.

Sixty-six years old and a native of South Carolina, Col. Johnson is serving his country in war for the third time. He was an artillery sergeant during the Spanish American War and was commissioned by Governor Manning of South Carolina to recruit a battalion of military engineers for immediate overseas duty with the Rainbow division in 1917. He saw action in virtually all of the major engagements in France, first as a major, then as a lieutenant colonel and, finally, as a colonel.

On his return from service, Col. Johnson resumed the practice of civil engineering at Marion, S. C. His specialties were timber, drainage, roads, bridges and utilities.

From 1911 to 1914, Col. Johnson was chairman and chief engineer of the Marion County, S. C., Highway Commission for the expenditure of the first road bond issue in the state, which resulted in the construction of 75 miles of roads and 27 bridges. In 1916, at the request of the governor of South Carolina, he recruited a company of military engineers that served on the Mexican border, and shortly thereafter was named first chairman of the South Carolina State Highway Commission.

NEW WARTIME EDITION

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BULLETINS

WELL BOTTOMED AT 15,270 FT.

MIDLAND, Tex. — Phillips Petroleum Co.'s No. 1 Ada C. Price test well in Pecos county has been bottomed at 15,270 feet, 266 feet below the world's drilling record, the company reported on May 2. Phillips' officials said the well is shut down for repairs.

* * *

INDIVIDUAL SUBSIDIES OKAYED

WASHINGTON—After reviewing OPA's stripper well subsidy plan, the national production committee on May 2 decided to recommend that P.I.W.C. issue a statement reaffirming its opposition to subsidies but declaring its desire not to stand in the way of any operator who feels he needs government aid to continue in business.

Our Cover

NPN's cover this week is a reproduction of a drawing prepared under auspices of the U. S. Navy and serves as part of its contribution to the nation-wide observance of 100-octane week May 1-7.

It was just 10 years ago that the Shell refinery at Wood River, Ill., delivered to the Army its first consignment of aviation gasoline, and there was not a large production of the super fuel until Pearl Harbor drew America into the war. Today Allied production is more than 400,000 b/d and the output is being stepped up daily.

"Thanks for that 100-octane advantage!" says the young flier in the Navy poster.

And that echoes the sentiments of every youngster who flies and fights for freedom under the banners of the United Nations.

The tributes being paid this week to the industry and industry workers are well deserved.

NATIONAL PETROLEUM NEWS—May 3, 1944—Vol. XXXVI—No. 18. Published every week at 1213 West 3rd St., Cleveland 13, Ohio, U. S. A. Subscription rate $5.00 per year in United States, Mexico, and Pan-American countries; $6.50 Canada and foreign countries. Entered as second class matter Jan. 17, 1910 at Cleveland, O., post office under act of March 3, 1879, by The National Petroleum Publishing Co.

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NATIONAL PETROLEUM NEWS
NPN
NEWSMAGAZINE FOR OIL MANAGEMENT MEN

Anglo-American Oil Commission Planned

Temporary Board Would Confine Activities to Export Field; Senate Oil Group's Open Hearings Delayed Indefinitely

NPN News Bureau

WASHINGTON—Creation of a temporary joint British-American Commission, charged with the task of integrating export demand and supply, may be one tangible early result of the oil talks that come to a close here this week.

The commission, establishment of which will be recommended by the conferees to the top flight policy committees representing the two nations, would serve in a purely advisory capacity and would continue in existence only until such time as some sort of permanent international machinery, patterned after the Interstate Oil Compact and embracing all producing countries, can be set up.

As envisioned by the Anglo-American technical experts, the joint commission would function in much the same manner as did the U. S. Bureau of Mines before war forced discontinuance of its monthly state-by-state forecast of daily demand. Individual producing states were not compelled to follow those estimates, but used them as a guide in setting production rates, etc., and the expectation of the conferees is that the recommendations of the British-U. S. group would be similarly used.

Deal With Exports Only

One thing emphasized to NPN by official sources is that the recommendations of the proposed advisory group would be concerned solely with the relation of supply to export demand.

It is recognized by the British as well as the Americans, it was said, that the commission could not properly concern itself, for instance, with the rate of crude production required in the U. S. to meet purely domestic demand. In other words, NPN was informed, there is no intention to allow the commission to interfere in any way with production matters that are properly the concern only of the U. S., but rather to confine its activities strictly to the export field—to the job of suggesting what export market should be supplied from where and in what volume.

The recommendations of the technical experts, including the idea of a temporary joint commission, are to be embraced in a final report now being drafted and which will be submitted to the top policy committees within the next day or two, upon adjournment of the present conferences.

Actual contents of the report are not expected to be made public until sometime after the American committee, headed by Secretary of State Hull and the opposite British group, which has yet to be named, have had opportunity to review them, possibly in a joint session that may be held here in the next three weeks or so. Decision as to whether a joint meeting will be required will be made shortly.

Meantime, the Senate national oil policy committee postponed indefinitely the start of formal open hearings, yielding to a request for delay from Secretary Ickes. The committee was to have begun public sessions May 2.

Mr. Ickes based his plea for postponement on the grounds that it would seem inappropriate to inaugurate open hearings at a time when "representatives of Great Britain and the U. S. are holding important conversations with respect to the world oil situation."

Ickes Outlines Reasons

"These conferences," he wrote Chairman Maloney, "are not at a policy making level. Some time ago, the president appointed a committee of which Secretary Hull is chairman, and the British government was invited at the same time to appoint a corresponding committee. To this senior committee, as I understand it, a report will be made by the junior committee which is now at work, and the senior committee, it is assumed, will consider any report presented for affirmation or for modification.

"Public hearings on the oil situation, including the proposed pipeline from Saudi Arabia to the eastern Mediterranean, should, it seems to me, properly be postponed until we can see more clearly what lies ahead."

Sulfur Is Low in Gasoline Of New Mississippi Field

Special to NPN

PITTSBURGH—Sulfur content of motor gasoline made by straight distillation from crude from the new Heidelberg field in Jasper County, Miss., is low, although the crude itself runs around 3% sulfur, officials of Gulf Refining Co. report.

Tests made from crude from the Gulf company's Lewis-Morrison No. 1 show a 19% yield of motor gasoline, of 0.04% sulfur content.

Typical virgin yields and tests of products from crude from the Lewis-Morrison No. 1, which is 25.2 gravity A.P.I., are as follows:

Motor gasoline: Yield, 19%; sulfur, 0.04%; octane number, 38.

Distillate fuel oil: Yield, 15%; gravity A.P.I., 42.5; end point, deg. F., 525; sulfur 0.85%.

Residual fuel oil: Yield, 65%; gravity A.P.I. 15; SU viscosity at 100 deg. F., 3000; sulfur, 4%.

PAW Estimates Effect Of Stripper Plan

NPN News Bureau

WASHINGTON — PAW Production Director Knowlton, May 2, urged members of P I W C's production committee to carefully consider OPA's proposal dealing with stripper well subsidy payments, observing that "there is every indication that your judgment and that of PAW will carry great weight in Judge Vinson's decision" to accept or reject it.

The committee was asked to take "appropriate action" regarding the proposal at the current meeting and was presented with tables showing the estimated production which would be affected under the OPA plan and the estimated dollar payments which would be necessary.

Data used in compiling the summary was based upon daily average production at end of 1943 divided by producing oil wells at the end of the year, by fields. Pertinent statistics derived from PAW's estimate are summarized as follows:

Total number of fields affected, 500.

Total number of wells affected, 258,476.

Daily average production affected, 412,872 bbl.

Annual production affected, 150,698,280.

Total daily average payments, $149,438.

Total annual payments, $54,544,890.

Average payments on production affected, 36cts per bbl.

Average payments on nationwide production, 3.5cts per bbl.

Annual payments—Penn grade area, $18,149,625.

Percentage of total payments—Penn grade area, 33%.

District 1	100%
District 2	17.2%
District 3	5.5%
District 4	20.4%
District 5	4.1%
Nationwide	9.5%

Death Claims H. H. Champlin

ENID, Okla.—H. H. Champlin, who organized and owned the Champlin Refining Co., died here April 30 at the age of 76. The merchant-banker-oil man was one of Enid's pioneers, coming to Oklahoma from Kansas when a young man.

Shell Co. Marks '100-Octane Week' by Dedicating New 'Cat' Cracking Units at Wood River, Ill.

By V. B. Guthrie,
Associate and Technical Editor

ST. LOUIS — On the same plant site where, ten years ago to the day, the first shipment of 100-octane gasoline was made to the U. S. Army, a time capsule was buried with fitting ceremonies on April 30 at the dedication of the new twin catalytic cracking units of Shell Oil Co. Inc., at its Wood River, Ill., refinery. The ceremonies also marked the opening of "100-Octane Week", to bring to the nation's attention the great service the oil industry has achieved in supplying our own and Allied fliers with a great volume of aviation gasoline superior to anything our enemies can produce.

The first delivery of 1000 gallons of the then "super" aviation gasoline on April 30, 1934, as commemorated in the time capsule, was from a production of only a few hundred barrels a day at the Wood River plant. It was a straight-run gasoline, made from selected crudes, with Ethyl fluid added to bring it to 100-octane.

Today, total output of aviation gasoline at Shell's Wood River plant is around 15,000 b/d, enough to send 400 bombers a day overs the longest mission in Europe. Much of it is superior in quality to 100-octane fuel.

The hermetically-sealed time capsule contains a sample of the original aviation gasoline, the formula for its manufacture, copies of the contracts for deliveries, and also a scroll commemorating Shell Oil Co.'s contribution to the development of aviation, for some future generation to read.

"This scroll simultaneously commemorates two related events," states the document, which is signed by Alexander Fraser, president of the company, "which draw their significance from the fact that they symbolize the progress made in one industry during the brief space of a decade.

"The first of these events is the tenth anniversary of the development of the first 100-octane gasoline ever produced in commercial quantities. The second is the completion of a huge new plant, producing gasoline of far higher than 100-octane quality.

'Shapes Outcome of Struggle'

"But this scroll must do more than merely commemorate these events. It must also set forth the conditions that make them seem worthy of commemoration. As this is being written the world is writhing in the throes of the greatest military struggle in its history. It is a conflict of opposing ideals. The outcome of this world-wide war may well determine whether the men of the future who unearth and read this scroll will have made greater progress toward the attainment of mankind's ultimate goals than we have made during a like span in our history. But of this much we are certain: The events this scroll commemorates are playing a significant role in shaping the outcome of this struggle."

The burying of the time capsule was only a part of the ceremonies dedicating Shell's new fluid catalytic cracking process units. Robert P. Patterson, under secretary of war, spoke twice at the refinery; by radio on the Army Hour program, to honor "100-octane Week" and during the formal dedication ceremonies. Several thousand Shell workers, their families and friends, gathered under a huge pavilion to hear Mr. Patterson and other speakers tell of the part the American oil industry is playing to winning the war by supplying super quality aviation gasoline. The United Nations' production of 100-octane gasoline has now reached the volume of 400,000 barrels a day, said Mr. Patterson, the greater part produced in this country.

Mr. Patterson presented figures showing the extent of bombing in recent weeks of Europe and other theaters of war. "Our 100-octane gasoline has also played a great part in a development of this war that has meant the difference between life and death or being permanently crippled to thousands of American soldiers," he said. "The U. S. Air Force carried back to hospitals 18,000 sick and wounded from the African theater. They ferried 17,000 more from the New Guinea jungles to Port Moresby. Had the planes used lower octane fuel, 30% of these men could not have been moved.

"Quicker take-offs and make-shift runways, greater load lifting power, longer range; these advantages come from the work done at the 100-octane refineries . . . . If you could see our transport planes with giant gliders in double tow behind them, you would realize where American aviation is going as long as

Mrs. Doolittle Takes Part in Wood River Ceremony

Time capsule containing one gal. of original 100-octane gasoline and copy of the contract with the Army Air Forces under which the Shell Oil Co. shipped the first super fuel, April 30, 1934, is being lowered into a monument by (left to right) Alexander Fraser, president of the Shell company; Mrs. James Doolittle, wife of the flying hero, Lieut. Gen. Doolittle, and Under Secretary of War Robert P. Patterson, at Wood River, Ill., where the company commemorated the tenth anniversary of the first commercial delivery of the fuel

you will fuel their planes with more and more power. That job is up to you," he told the refinery crews.

President Fraser spoke of the achievements of industry in this country in meeting the demands of global war. "The American system, the system in which management and labor have judiciously used the collective capital of millions of investors, has not only survived these years of economic upheaval and the mortal peril of war," he said, "but has gone on to prove that this tri-partite group working together can accomplish miracles . . . .

Fraser Lists Advantages

"It has far exceeded the production of our enemies who had been stealthily preparing for war for ten long years," said Mr. Fraser. "It has given us the largest navy in the history of the world. It has enabled us to produce a volume of merchant ships during the last year far exceeding the production of all other countries in the world combined. Not only have we been able to supply and equip eleven million men in our armed forces scattered over the face of the globe, but in addition we have also been able to send substantial quantities of supplies across the seas to assist the United Nations."

Speakers at the dedication ceremonies besides Under Secretary of War Patterson and President Fraser were: R. C. Roberts, manager of the Wood River refinery; Hugh W. Cross, lieutenant governor of Illinois, Rear Admiral T. Earle Hipp of the Navy Bureau of Supplies and Accounts and Maj. John D. Craig of the U. S. Army Forces.

° ° °

United Nations 100-octane Output Tops 400,000 b/d, U. S. Reveals

NPN News Bureau

WASHINGTON—The United Nations as of May 1 will be producing 100-octane gasoline at a rate greater than 400,000 b/d, it was revealed at a press conference attended by PAW Ickes, Assistant Deputy PAW Brown and Army and Navy officers in the Interior Department April 28, preparatory to "100-Octane Week" (May 1-7), which will be observed on the tenth anniversary of the super-fuel in tribute to the oil industry's management and labor for the job they have done stepping up production of aviation gasoline.

This figure is about ten times the output of all refineries and synthetic plants in Axis Europe before round-the-clock bombing began to take a great toll of enemy war facilities, newsmen were told.

Highlights of the press conference, led off by Mr. Ickes, with Mr. Brown supplying technical explanations, follow:

1—"Today's Allied production of more than 400,000 b/d—enough fuel to send 10,000 planes over Berlin every day in the year, if we wanted to use it that way—still isn't all we need or all we are going to get."

2—Total cost of all new aviation gasoline facilities, world wide, will be in neighborhood of $900,000,000, of which $760,000,000 will be for plants in U. S.

3—Eighty-two per cent of ultimate capacity of 100-octane plants in U. S. will be privately owned. In terms of investment, private companies will have obligated roughly $550,000,000 of their own money in expansion of 100-octane facilities between Pearl Harbor and end of 1944. Government investment in same period will come to about $210,000,000.

Small Companies Help

4—At rate of U. S. 100-octane production on May 1, every man working in plants would be personally responsible in course of a year for making 38,000 gallons of this fuel. It takes 140,000 men to operate aviation gasoline plants, and various components which are blended to make the fuel.

"The larger oil companies refine about four-fifths of the nation's crude oil, but the job of making 100-octane gasoline was not assigned exclusively to them," Mr. Ickes pointed out. "Some 35 of the smaller refiners have been brought directly into the program and 16 of approximately 70 major 100-octane producing units have been entrusted to their care."

The story of what the oil industry was able to accomplish in obtaining more aviation fuel in a hurry with one hand, while putting up new facilities with the other, was a typical example of American ingenuity and co-operation. Here are a few of the accomplishments:

1—Seventy-two smaller units were converted from making motor gasoline blending stock to turning out 100-octane ingredients.

2—Fourteen catalytic cracking plants, which had been employed for the same purpose, were switched over early in 1942 to producing base stocks for 100-octane.

3—Polymer plants, which likewise made "cream and sugar" for motor gasoline, were modified so they could make a high-octane blending agent called codimer.

4—All refineries in the U. S. were operated under PAW as though they were part of a single unit.

5—Altogether there were some 200 major and minor projects of conversion,

Military Chiefs Laud 100 Octane Workers and Industry

"To Workers and Producers of 100-Octane:

"On this tenth anniversary of 100-octane gasoline, the Army Air Forces extends its congratulations. You workers and producers deserve the recognition of '100-Octane Week' for you have won a battle. This has been a victory of prime importance for without it the victories that take place daily in the skies would be impossible. You have supplied the fuel to power our aircraft in the past and the AAF can plan even greater blows to the enemy with confidence that you will not fail us in the future."

H. H. Arnold
General U.S. Army,
Commanding General
Army Air Forces

Gen. Arnold

Admiral King

"On this tenth anniversary of 100-octane, the Navy salutes the thousands of men and women of the petroleum industry whose efforts have made possible the production of this fighting fuel. One-hundred-octane gives us an advantage in the air. It puts our fliers on top—and keeps them there. The constantly intensified war in the skies requires more 100-octane production without delay. The Navy is confident you will wholeheartedly meet this challenge to help speed the wings of victory."

Ernest J. King,
Admiral U. S. Navy,
Commander-in-chief U.S. Fleet

alteration and adaptation of existing facilities to bridge the gap until the new plants could be constructed.

6—As a result, the average yield of 100-octane fuel from a barrel of crude was increased from .21 bbl. to .42 bbl.

7—Sixty-five per cent of the increased output of 100-octane during the first two years after Pearl Harbor was figuratively taken out of a hat by chemical magic and mechanical adjustments. Although 41 major units were completed in that period, only 35% of the increased and 20% of the total octane came from the new plants. For the rest, we must credit the ingenuity of the petroleum industry.

A Peacetime Resource

The nation's $760,000,000 outlay for new 100-octane aviation gasoline facilities should be a sound peacetime investment as well as a powerful war weapon, according to the PAW-prepared resume.

"Because of the flexibility of modern refining equipment, the industry will not be faced with the alternative of continuing to turn out high-octane aviation gasoline in wartime quantities or of abandoning its huge investment altogether," the report said.

"For one thing, expansion in both commercial and private flying is expected to provide a continuing market for considerable quantities of aviation fuel. For another, many of the new catalytic cracking units that have been built as part of the war program can be converted to peacetime use to increase both the quantity and quality of postwar motor gasoline. To a certain extent, the same can be said of facilities for producing various types of blending agents used in 100-octane fuel."

I. P. A. A. Board Hits U. S. Meddling in Industry

Special to NPN

BRADFORD, Pa.—Government participation in the oil business drew a stern frown from the board of directors of I.P.A.A. in resolutions adopted at the conclusion of the three-day mid-year meeting here, April 29.

In the series of resolutions, the directors applauded the appointment of a Senate committee on national oil policy and pledged "our efforts and our support in its coming investigation."

The I.P.A.A. reaffirmed its opposition "to the encroachment of the U. S. government into business in competition with private industry. Congress is requested to reject Senate Bill 1773 insofar as said bill would permit condemnation of privately-owned or controlled oil lands within and contiguous to Naval reserves."

The Association expressed opposition "to government participation in the oil industry in general and to the Saudi Arabian pipeline project specifically."

Other resolutions adopted follow:

EMERGENCY PRICE CONTROL: "We petition Congress to renew the Emergency Price Control law and in renewing said law that the same be amended to provide more certain and definite standards to guide that office in administering provisions of price control as affecting crude petroleum and its products."

MANPOWER: Asked "that the Petroleum Administrator for War make strong application to the government agency concerned to secure deferments for men engaged in essential work in this industry so that the exploratory and development program recommended by the law can be fulfilled."

CO-OPERATIVES: The association urged that Congress "provide for the application of income tax laws to all co-operative associations engaged in the production or distribution of goods and commodities," except for those marketing farm goods.

WELL SPACING: Recommended the Petroleum Administrator for War decentralize its regulations and administer them through local divisions.

At the morning session of the final day, Rep. Disney, Oklahoma, disclosed that he plans to introduce a bill in the course of "the expiration of every executive order, rule or regulation at the end of each two-year session of Congress to make a complete check of the executive department of our government."

He also sought support for a measure whereby income tax will be limited by constitutional amendment to 25% in peace time.

Raymond B. Moley, *Newsweek's* editor on national affairs, speaking at an "off the record" luncheon, April 29, warned against the trend toward class distinction in politics and urged a return to party division.

A warning that the Arabian pipeline is a threat to our national security was sounded by both Governor Edward Martin of Pennsylvania, who spoke on the opening day, and Ralph T. Zook, I.P.A.A. president.

"The proposed Arabian pipeline may easily lead us into a third World War," Governor Martin stated. "It will cost American taxpayers not less than $160,000,000. The money for the prosecution of the war can be much better used in the development of our own home fields. Arabia is on the other side of the world. Always remember that armies and nations should retain control of their source of supply."

Governor Martin charged that the New Deal and its economic fascists want to control the oil business. "That must be prevented," he warned. "I sincerely believe the salvation of America depends upon maintaining free enterprise at home."

Mr. Zook, in his talk, feared that the building of the Arabian pipeline at this time would lead to a permanently depressed domestic oil industry which, in turn, would threaten the safety of the country in the event of future wars.

"Because of the economic and competitive conditions in the Middle East," Mr. Zook said, "the laying of this pipeline at this time can bring on the market an additional 600,000 bbls. of crude oil daily.

"If this oil does not appropriate the European and African market, then this 600,000 bbls. daily of new production will be 'knocking at the door' of the U. S. on a competitive basis which will freeze the price of our domestic oil at not above and perhaps below the present level."

Report Solid Gains Attained In East Coast Oil Studies

NPN News Bureau

NEW YORK — Fundamental research work to determine the place of the small marketer in the oil industry was ordered continued by the Atlantic Coast Oil Associations Conference at its third annual meeting at Commodore Hotel here on April 26. Approval was voiced of the progress made to date by Secretary Clyde G. Morrill in the research.

Studies of taxation, new and old products which are part of the petroleum distributor's marketing operation, cost of operation and interindustry relationships were also proposed. Studies of specific markets will follow.

It was also unanimously voted to reorganize the conference for a greatly expanded job this year, and a committee, headed by H. B. Van Cleve of the Maritime Petroleum Corp., was directed to formulate a detailed program to be reported at an early meeting.

The meeting reviewed the past year briefly, noting as a matter of accomplishment, that the activities of the conference had contributed heavily to a much smoother operation of PAW, ODT, OPA and manpower regulations.

Increased spread on fuel oils, gained largely through the conference's presentation, has meant an additional return to retail distributors of range oil and distillate of almost $10,000,000 on the Atlantic Coast alone. The fight for DSC compensation for the 3% transportation tax has resulted in at least $400,000 more in independent primary supplier's returns, the report points out.

It was also revealed that the conference had made numerous spot checks to provide Washington agencies with factual information on changing conditions in distribution, particularly consumer rationing.

In addition, the conference helped instigate and form the gasoline and fuel oil jobbers subcommittees in PAW and the advisory committees in OPA, local and national. More than 100 pages of special reports have been issued to members during the year and all important WPB, PAW and OPA printings have been distributed. Constant contact is being maintained with all regulatory officials in government departments, as well as legislators in Congress. Close contact is already established with the newly formed Small Business Division of the Bureau of Foreign and Domestic Commerce in Washington.

Tanham Heads Industry Group Revolt Within WLB Demanding Judicial Review On Union Security

NPN News Bureau

WASHINGTON — Flatly rejecting a majority decision of public and labor members granting union employes a maintenance - of - membership provision, the industry group, led by an oilman, James Tanham, a vice president of The Texas Co., shook the War Labor Board on April 29 by requesting a judicial review of the board's authority to grant union security.

The decision, which marked a complete break between the majority and the industry members on the union security issue, was made in the dispute involving employes of the Humble Oil Co., Ingleside, Tex., who are members of Local 316, Oil Workers' International Union, C.I.O.

The policy of the board in providing for maintenance of a voluntarily established union membership has become "the equitable and stable foundation for co-operative industrial relations and stands justified by the American record of production for the war, unmatched anywhere else in the world," public members of the board declared in their written opinion.

Doubt Production Helped

By a vote of 8 to 4, with industry members dissenting, the board granted its standard voluntary maintenance of membership clause to the union, thus reversing the action taken by the Eighth Regional Board at Dallas, which had rejected the union's demand for a maintenance clause.

The labor members wrote an opinion concurring with the majority opinion and replying to the industry opinion, in which the dissenting group declared that after more than two years of contention by the majority that union maintenance helped production, it had received no demonstration of that assertion, but had found, on the contrary, many cases in which the reverse was true. Industry members cited the coal and steel strikes.

Mr. Tanham's declaration that, in his opinion, the granting of union maintenance was "unlawful" and that the matter should be submitted to a court test drew a sharp answer from Chairman W. H. Davis.

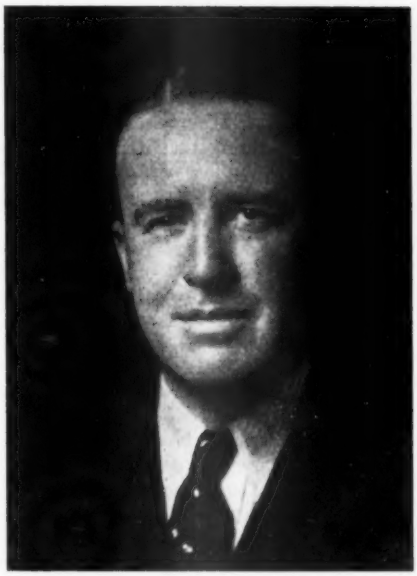
If Mr. Tanham were supported in his opinion, Mr. Davis suggested that one of them would have to resign, since the same board which disagreed on the lawfulness of a directive could not enforce it.

Softening Mr. Tanham's dissent somewhat, the industry members, in their opinion, stated:

"Because of the frequent challenge, by learned counsel, of the board's authority to impose its form of maintenance, we would welcome a judicial determination of that question."

The board based its reversal of the Dallas board's rejection of the union's demand for a maintenance clause on the ground that "the rejection of the provision for the maintenance of the voluntarily established membership of an acknowledged responsible union was a contravention of the policy of the National Board".

The main foundation of this national policy, declared Dr. Frank P. Graham, who wrote the opinion for the public members, are twofold, one, that "the maintenance of a voluntarily established maintenance union membership is a national necessity for the stabilization of union-management relations during the war" and, two, that such maintenance of membership as an equitable necessity "is reinforced by the act of Congress requiring stabilization of wages".



James Tanham . . . . doubts union maintenance spurs production.

The best answer to the question as to whether WLB has a maintenance of membership policy is in the record, Dr. Graham stated. He revealed that in 291 cases involving maintenance of membership, the board, between Jan. 12, 1942, and Feb. 29, 1944, had decided 271 cases in favor of maintenance of membership and in two cases submitted the issue to a referendum of the employes. The provision was denied in 18 cases. Regional boards and commissions granted maintenance of membership in 783 cases, denying it in only 34. More than 1,760,000 workers were involved in the national and regional cases, it was pointed out.

Fear Industrial Disruption

The public members' opinion recalled that the necessity for the stabilization of unions in a world at war was made clear during the early days of the National Defense Mediation Board, when the most explosive issue was the open shop demanded by management vs. the union shop championed by unions.

"These two positions," the opinion declared, "honestly and stubbornly held, if unreconciled, would result in industrial disruption and the monthly loss of many millions of man hours in production."

Concerning the board's decision in the Humble case, the opinion stated that "on the record in this case, the union is democratic in organization and is responsible and co-operative in the maintenance of the contract and in keeping the no-strike pledge."

The industry members' dissent, in part, stated:

"The issues raised by this case and by the majority before us requires a frank and forthright statement.

"We are confronted with a theory of finality in the decisions of this governmental agency, without provision for judicial review, to which we cannot subscribe. We find expressed in the majority opinion a flood of idealistic declamations but a dearth of demonstration. We assert that the philosophy expounded by the majority leads inevitably to denial of the very ideals for which our country is fighting the present war. We condemn the majority proposed policy on union maintenance because, in our opinion, its application contemplates widespread undemocratic restriction of the rights of workers and of employers; because it would spread more or less indiscriminately in industry a device unproved as an aid to production; and because it would constitute a potent threat to harmonious industrial relations so necessary now and in the postwar period.

Contrary To Democracy

"More specifically, we dissent because:

"1. It is contrary to the principles of democratic government for this, or any other governmental agency, to make union membership a condition of employment.

"2. After more than two years of contention by the majority that union maintenance, can be and has been used offered no demonstration but, on the contrary, find in many cases that the reverse has, unfortunately, been true.

"3. So-called union maintenance, now to be a board policy, has permitted the use of a worker's money, dues and assessments, for political purposes contrary to the worker's personal choice and ideas.

"4. It is an affront to the patriotism of American workers for an agency of this government to offer material reward for a no-strike pledge in time of war.

"5. Union discipline, whether made possible by a union shop or by union maintenance, can be and has been used to halt production and to force action by the government, including this board. The majority policy contains no provision against repetition.

"6. The majority policy, even if otherwise unobjectionable, is no guarantee of alert and responsible union leadership.

"7. We believe that the national board's action in this case will result in a loss of prestige and of stabilizing in-

(*Continued on p.* 54)

Highlights of 1944-45 Fuel Oil Ration Changes Revealed by Whitman; New Dates for Periods

NPN News Bureau

WASHINGTON — The thinking of OPA fuel rationing officials on several specific angles of next season's fuel oil rationing program has nearly crystallized, and details on period dates, thermal periods, early summer deliveries, minimum dumps on "extra" allotments, hardship rations and expansion of ration banking will be presented fully in OPA's next Fuel Oil Industry Letter.

A discussion of several points treated in the industry letter, which is now at the printers, has been made available to NPN through the co-operation of Al Whitman, OPA fuel rationing chief. Highlights follow.

First, as to period dates: The new 1944-45 coupon will be almost identical with last year's and will contain both inventory coupons and change makers. However, dates for the periods will be changed. Last year the dates were set on a nationwide basis (except in the South) so that about 20% of the degree days fell in each period. This meant that a considerable part of the ration—nearly 40%—was validated on July 1 and could be used in period I.

Under that plan, there was no encouragement for proper consumer budgeting while those who were overconsuming did not come in to local boards until rather late in the year, both of which conditions were undesirable.

Two Proposals Made

Two proposals were made to correct this situation: one was completely to eliminate the inventory coupons, the other to put higher percentage of degree days in the first period, thus making the start of period 2 fall on a later date. OPA has decided on this latter plan because of the need for program flexibility.

No final decision has been made on the number of degree days that will go into each period, but OPA contemplated 30% in the first period; 15% in each of the next three periods; and 25% in the fifth period. This arrangement will automatically advance the validity date of period 5 coupons by about two weeks. These dates have already been checked by OPA with its field organization and OPA is now checking them with its industry advisory council.

Under the contemplated period arrangement outlined above, adequate coupons should be available to make good summer deliveries, OPA believes. After the first period is over, delivery problems for the rest of the year should be considerably eased, it is pointed out. At the same time, the new degree-day period system will help keep the consumer supply more definitely related to degree-day requirements. The most obviously wasteful consumers, Mr. Whitman points out, will have to come in to the boards earlier in the year for additional rations, which will give the boards a chance for careful review.

In the letter now ready to go to the industry, Mr. Whitman has taken up a number of industry suggestions, giving reasons for OPA's decision.

On the subject of thermal periods, he has pointed out that OPA has received a large number of recommendations regarding the period setup, ranging from complete elimination of all periods to every conceivable alternative. Most frequent recommendation was for a straight three-period setup for the entire rationed area.

5 Periods to Continue

OPA's decision is to continue the present five-period arrangement, again permitting the combination of periods 2 and 3, 4 and 5, in the Midwest and South, and hoping that it may be possible to also combine periods 4 and 5 in the East later in the season, if the supply situation warrants.

Compelling reason for this, said Mr. Whitman, is the necessity of maintaining a tight, though flexible, control over fuel oil use. In addition, PAW strongly urged that the five-period system be continued next year.

On the question of summer deliveries, OPA received a number of suggestions that these be permitted to begin after May 1 or June 1. Actually, OPA has decided that the new 1944-45 coupons will be made valid as of July 1 and everything possible will be done to forward the necessary material to boards in time to start coupon issuance as of that date.

July 1 is apparently the earliest possible date that can be met. OPA is loath to accept any kind of coupon credit plan permitting earlier deliveries and believes the industry is just as anxious to avoid coupon credit.

One of industry's most important recommendations, said Mr. Whitman, was that OPA change its regulations to eliminate, as far as possible, the number of "bobtail" deliveries incurred in issuance of extra rations. Proposals along this line, advocated to save manpower, trucks, and tire wear and other delivery economies, took several forms, including:

1. No delivery to central heaters under, say, 100 or 150 gal., or 25 to 50 gal. to space heaters.

2. That in no cases, except possibly where supply conditions are unusually tight, should boards issue a hardship ration in an amount "below that required to put the consumer back on his ration for the rest of the year."

3. That prior to period 5, a system of coupon exchange be reinstated in the regulations whereby a consumer, or his supplier, could bring his coupons into his board or any board to exchange coupons not yet valid for currently valid coupons.

4. Or as an alternative, that suppliers be permitted to extend coupon credit to their customers.

5. That prior to issuance of the 1944-45 rations, boards be required to re-examine all cases where consumers had been granted extra rations, granting increases if needed—perhaps within the limits of a maximum increase.

Outlines Conclusions

Each of the above recommendations, and others, have been discussed within OPA and with industry committees and members, said Mr. Whitman. He outlined OPA's conclusions:

"We will endeavor to work out a plan whereby boards can send to district offices reports and recommendations to increase the annual rations of those hardship applicants who have tried conscientiously to conserve but have proved that they just can't get along. This will help eliminate multiple hardship grants and reduce small deliveries.

"Some kind of coupon exchange will be permitted before period 5 in cases where bobtail deliveries are otherwise involved. Under the contemplated plan, applications can be made by the consumer or by a supplier for the consumer. Boards will be given the option of permitting the exchange, or issuing a hardship ration.

"Barring unusually tight supply conditions, next year our instructions will clearly state any extra ration granted should be sufficient to put the applicant back on his ration for the rest of the heating season.

"Requirements that the applicant must have made 'reasonable efforts' to conserve will be continued. So will the provision that the amount issued shall be the minimum to avoid undue hardship. This means that boards who are certain that increased conservation is clearly possible, can and will undoubtedly take the opportunity for conservation into consideration.

"If our study of hardship cases indicates the need for further revisions, they will be made.

"We believe that the above innovation

should provide real relief within the framework of sound rationing procedure. Small deliveries after period 5 are, in our opinion, a problem of economy, not manpower or truck wastage. We cannot consider any proposal that would give an extra bonus to an over-consumer, or any plan that involves coupon credit."

More suggestions were submitted on hardship rations than on any other subject, Mr. Whitman said. One recommendation was to permit non-residential premises to be eligible for additional rations in cases of undue and immediate hardship. Amendment 2 to ration order 11 has been put into effect and this recommendation is now operative.

The fuel ration chief said many recommendations were received from dealers and associations on the hot water ration question, the consensus being that current formula was inadequate. An increase of 50% was requested and a number of OPA's field officials agreed, Mr. Whitman said, and continued:

"Actually, facts available to us indicate that the problem lies not so much in the allowance, but in the fact that consumers have not been convinced of the necessity for cutting hot water use to save oil.

Mr. Whitman admitted frankly that OPA has not done a good job of consumer education on the hot water conservation phase of the fuel oil rationing program and said a real effort will be made to correct this weakness.

Boards have already been instructed, he said, on the procedure for handling applications for additional oil to take care of undue and immediate hardship arising from lack of oil for summer hot water.

Russell Brown Fights On for Crude Increase After Vinson Lists Reasons for Refusal

NPN News Bureau

WASHINGTON — Russell B. Brown, I.P.A.A. counsel, continued his fight for a crude oil increase this week after Economic Stabilizer Vinson termed pure "poppycock" warnings by industry representatives that a general price boost was necessary to avert a critical oil shortage.

Appearing before the House banking committee on May 1, Mr. Brown urged the legislators considering extension of OPA price powers to write specific crude price legislation into the new act. Contending that OPA had interpreted the price control act in a lop-sided fashion—to hold down prices to stimulate production—Mr. Brown said the big question was one of "administration". He charged that there is a "deep-seated misconception of the law".

Some specific direction regarding crude prices must be taken by Congress, he added, or OPA will never recognize this basic principle—increasing prices to stimulate production.

In his appearance before the Senate banking committee last week, Mr. Vinson declared that events had proved he was correct in turning down requests for crude oil price increase.

Mr. Vinson said that there was much talk a year ago by the industry of an "oil famine", but that this had not developed. He then dragged the Arabian pipeline proposal into the argument, asserting: "Oil men say today there is a sea of oil lying under the U. S. and now think we have a tremendous reserve of oil. I believe the proposed Arabian pipeline might have had a little something to do with their present statements."

Vinson Cites Reasons

To back his argument that he was right in turning down requests for crude price increase, Mr. Vinson listed these points:

1—Importations from foreign sources have steadily increased. In this connection, Mr. Vinson said imports from the Caribbean area were now running about 180,000 b/d.

2—There was unprecedented demand for crude during 1943, and production of crude has also been unprecedented, keeping pace with the demand.

3—There are still 175,000 b/d of West Texas sour crude which could be used if there were sufficient transportation to carry it to idle refining facilities, and "that is being worked out and we have hopes that this movement will grow before long."

4—There was only a net loss of 18,000,000 bbl. in crude reserves at the end of 1943, compared with beginning of the year. "The cry that was heard," Mr. Vinson said, "was that we had to add to our reserves. In the first place, what are oil reserves for unless to use them in days like these."

5—Despite the declaration that present crude prices do not provide sufficient incentive to wildcatters, "figures show that in 1943 more wildcats were drilled than in all history. According to P.I.W.C. figures, only 2200 wildcats were drilled in 1937 and the number in 1943 was 3800."

"Proven Territory Best"

6—"If we need oil during wartime, proven territory is the place to go and get it."

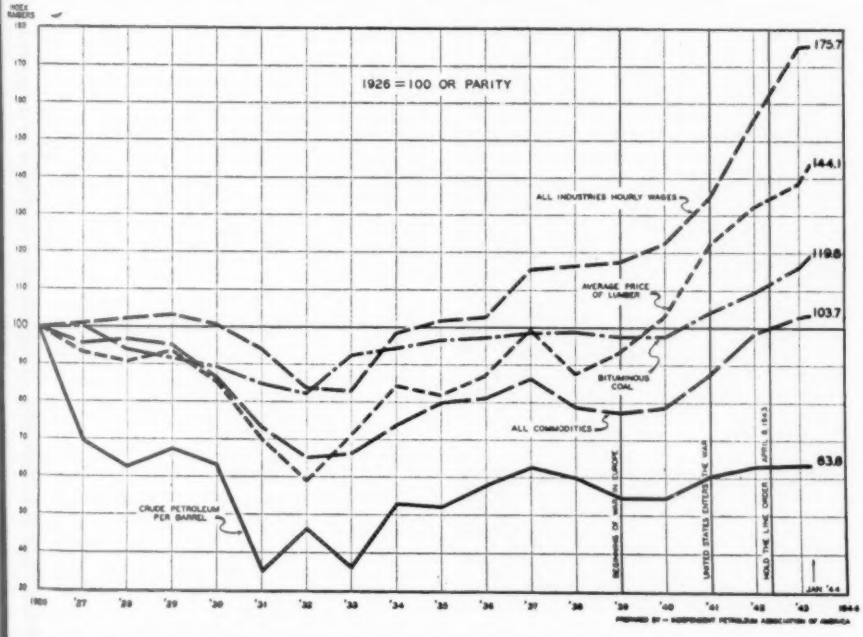
7—A program has been set up by PAW for 24,000 wells to be drilled during 1944, including 5000 wildcat wells, "and I am told that if that goal is reached, every well will be drilled that can be drilled, limited only by materials and manpower.

"I submit," Mr. Vinson declared, "that a 35c or 70c increase would not mean any more oil or any more oil wells drilled."

In attacking Rep. Disney's bill, which would bring crude prices up to parity, using the 1936 index as basis, Mr. Vinson said that if same principle were applied to other products, such as coal, gas, copper, etc., an additional 10 billion dollars would be added to prices of these products during one year period.

Mr. Vinson told the senators that no formal application for general crude price increase has ever been submitted to OPA by industry itself, adding that of individual petitions for adjustment

Chart Shows Crude Prices Trail Other Commodities



This chart showing average annual prices of crude petroleum (at the well), bituminous coal, lumber, all commodities and hourly wages in the U. S. was presented by I.P.A.A. Counsel Russell B. Brown in his plea for an increase in crude oil prices before the Senate banking committee on April 25

filed with OPA, 83 have been approved, nine disallowed, and five are still pending, or a total of 97.

Referring to Mr. Brown's testimony before the Senate committee early last week, that there were 4000 fewer wells producing at the end of 1943 than the end of previous year, Sen. Taft of Ohio asked Mr. Vinson for figures on well abandonments.

'Thinks' Figures Are Safe

Mr. Vinson replied that according to figures compiled by OPA from issues of an oil weekly, there were fewer well abandonments during 1943 than in any year since 1933, but when Sen. Taft remarked that his figures were in conflict with Mr. Brown's, the economic stabilizer said: "I think you can safely say that there were fewer wells abandoned in 1943 than in any year since 1933."

In answer to this testimony, Mr. Brown told the House committee this week that according to Bureau of Mines figures, there were 4171 fewer wells producing at the end of 1943 and 12 months earlier.

Mr. Brown also admitted in committee questioning that there were more wildcat wells drilled in 1943 than in previous years, but pointed out that these were drilled predominantly on reserves previously discovered, mostly by major companies.

He also told the House committee that the statement has been made many times by OPA that price does not have anything to do with drilling. On this, he showed a chart comparing well drilling with price over a number of years, pointing out how closely price and well drilling are related.

Before the Senate group last week, Mr. Brown said that the administration of the price control act with respect to petroleum prices had not conformed to the purposes expressed or the standards prescribed in the act and had been contrary to the best interests of the nation in the following particulars:

1.—Price ceilings were established by the OPA that were not fair and equitable and would not effectuate the purposes of the act in that the ceilings established were abnormally low. The price of crude petroleum was frozen, but the cost of the items entering into the production of petroleum was not fixed.

2.—There was no condition existing at the time of the imposition of these price ceiling orders to support, as to crude petroleum, such orders as defined by the act.

3.—There was no consultation with the representative members of the petroleum industry affected by the order. In fact, the administrative procedure established by OPA prevented such consultation and deprived the administrator of the benefit of industry opinion.

No Meetings Held

4.—The administrator, pursuant to authority given in the act, appointed some advisory committees within the industry but held no meetings with them and gave no heed to recommendations which they submitted voluntarily.

5.—The administrator refused to exercise his judgment to apply price ceilings on crude petroleum which all the facts indicated to be proper and necessary but on the contrary has long delayed the exercise of such judgment and discretion while he apparently searched for some other method of doing what Congress indicated he should do through proper price ceilings.

6.—A great deal of the funds made available to the OPA has been devoted to the division of the oil remaining after military requirements had been met between civilian and industrial users. This shortage, increasing with the growth of military demands, has been contributed to, if not caused entirely, by the failure of the administrator properly to administer the act as written.

Appeals Made Difficult

7.—Recourse to the Emergency Court of Appeals, provided in the act, was never possible because, to conform to the procedure of that court it is necessary for appellant to supply transcript of the proceedings before the OPA. It was never possible to institute a case and have hearings before OPA.

8.—Such consideration as was given by OPA to crude oil prices was limited to small portions of the daily production and not to the problem of supply as a national question.

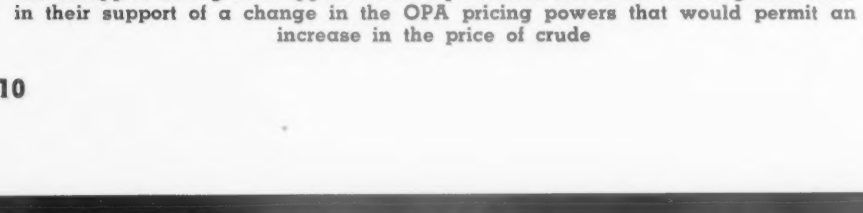
9.—Even on the limited and localized petitions for relief that have been placed before the OPA, the delay in arriving at decision has been unduly long and has subjected petitioners to unnecessary expense and waste of time. Any one of such petitions could have been decided within the matter of a few days. We charge generally that there has been evidence of a dilatory tendency which ill befits an agency created to aid in the prosecution of the war.

In apparent answer to Mr. Brown's charge that OPA has not complied with the price control act provisions calling for establishment of committees upon demand of substantial proportion of industry, the price agency, through Mr. Vinson, entered the following reply in record of the Senate banking committee:

"Petroleum branch of OPA has complied in every respect with OPA provisions of Section 2A of Emergency Price Control Act regarding appointment of industry advisory committees and consultation with such committees upon their request. At inception of price control under the act, 15* petroleum industry advisory committees were organized upon initiative of this office since no requests by substantial portion of industry were received to form industry advisory councils. Hence, despite fact that formation of such councils is mandatory under Section 2A of Emergency Price Control Act only where substantial portion of the industry requests it, this office proceeded almost immediately to establish an organization wherewith consultations with members of industry could be expedited.

"Committees in Disuse"

"Since that time, however, the industry has been reluctant to use these com-



Russell Brown, left, I.P.A.A. counsel, and James Brown, statistician for the organization, snapped during their appearance May 1 before the House banking committee in their support of a change in the OPA pricing powers that would permit an increase in the price of crude

* National Petroleum Industry Advisory Committee, East Coast Traffic Advisory Committee, Pacific Coast Traffic Advisory Committee, Natural Gas and Natural Gasoline Advisory Committee, Refined Products Prices Advisory Committee for Dist. 1, 2, 3, 4, 5, Crude Oil Prices Advisory Committee for Dist. 1, 2, 3, 4, and 5 and Petroleum Export Advisory Committee.

mittees as official advisors. We have, moreover, found that principal officials who were members of committees usually chose to delegate to subordinate operating personnel detailed questions arising out of price control. As a result, such committees have largely fallen into disuse. We have, however, organized on April 22, 1944, for purpose of studying important question of heavy fuel oil supply and prices, a fuel oil industry advisory committee and its members have recently been appointed.

"Formal committees organized under Section 2A of the act have not been the only groups with which this office has consulted. Petroleum industry has established an elaborate and representative system of industry committees which handle problems of price and supply on both national and regional basis. These sub-committees (district committees) operate under P.I.W.C. We have consulted with council and/or district committees on all questions relating either to price of crude petroleum or petroleum products. Since these committees have been advisory groups for PAW they are much better informed on problems of supply and price than any formal industry advisory committees which could otherwise have been appointed. We have asked them, on a number of occasions, to be formalized as industry advisory committees under Section 2A of the act.

"They have been reluctant to act in that capacity and have preferred to deal with this office on informal basis. Since these committees are probably most representative group which could be formed, and since we have received no requests from any substantial portion of industry for organization of additional committees, we feel that the procedure adopted by this office is compatible with intent of Section 2A. We have been highly successful in our dealing with district committees of P.I.W.C. We have not been informed of any dissatisfaction by industry or any segment of the industry with the method of procedure we have followed in consulting with P.I.W.C. groups."

Lending weight to general belief that he will endorse OPA's recommendation dealing with stripper wells, Vinson told committee that there are 300,000 to 400,000 such wells in the U. S. "which have less production per well and lifting costs are much higher per barrel but to make a long story short—I felt when I wrote my decision, that relief ought to be given to stripper wells. OPA has made a study of this at my request and has submitted a proposal which I have sent to the petroleum administrator for his consideration."

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Suspension Order Defense Presented by Polier As Only Means of Attack Against Black Market

NPN News Bureau

WASHINGTON — Resuming hearings on the gasoline black market, the special House oil investigating committee, whose chairman is Rep. Lea of California, May 2, heard Shad Polier, OPA fuel enforcement director, vigorously defend the suspension order system as the only practical means of mass attack against the illegal sale of gasoline.

At the same time, Mr. Polier referred to the Brockmeyer case which had touched off a series of indignant questions by committee members at a previous hearing (*see NPN, April 26, p. 3*). Mr. Polier said that he found himself in a rather embarrassing position in that he found it necessary to apologize to his staff. Since the previous hearing, he added, he had received a complete file on the case and has found that it is "not at all" the case of two elderly people having been "over-reached".

Mr. Polier said the case had been instituted because the Brockmeyers, in return for gasoline sold, had received improperly endorsed coupons as well as unendorsed coupons. There was no charge leveled against the couple for having taken counterfeit coupons, he added.

Rep. Harris, of Arkansas, remarked to Mr. Polier that "if you are going to use that (unendorsement of coupons) as a sanction against motorists, you had better get after me as well as many other motorists in the country". Rep. Harris said that he had received coupons from his local ration board and driven into a service station where the operator had endorsed them with his (Harris') license number. More recently, he added, he has put his license number on all of his coupons.

Rep. Brown, of Ohio, then asked Mr. Polier if the solution to entire endorsement problem would be to have local ration boards write the license number of applicant's car on all coupons issued to the motorist. Mr. Polier said this was being done in many districts, where local board manpower would permit. It would help a great deal if all local boards in the country could pre-endorse coupons, he added, pointing out that there would still remain the problem of counterfeit coupons.

In reply to a charge by Rep. Boren, of Oklahoma, acting as temporary chairman of committee, that OPA red tape is making violators of many thousands of American citizens who have no desire to break a law, Mr. Polier pointed out that issuance of rations is done through local boards, composed mostly of volunteer workers who have done a "tremendously fine job".

Mr. Polier's defense of suspension order system was contained in a statement which he read to the committee. Excerpts from the text follow:

"Whatever the decision of the Supreme Court, OPA had no alternative except to set up a suspension order procedure which it reasonably concluded (and which the courts thus far have concurred in) was within its authority under the Second War Powers Act. Indeed, if the Second War Powers Act does not, in its present form, permit the setting up of such a system of administrative hearings, the public interest would require amendment of the legislation so as to provide that authority.

"Protection of the integrity of the rationing system is alike in the general public interest and of honest business. That protection depends upon effective enforcement. Out of the experience of nearly one year and a half of rationing emerges unmistakably the conclusion that enforcement is and will continue to be utterly impossible without an administrative remedy being available to OPA. . . .

3,008 Prosecutions Instituted

"The remedy of criminal prosecution has not been neglected. Up to April 1, 1944, 3,008 prosecutions have been instituted by U. S. attorneys upon the recommendation of OPA and 2,283 convictions secured. Only 169 cases (amounting to 6.9%) have resulted in acquittals or dismissals. A very substantial part of the criminal cases have involved professional criminals, ranging from those counterfeiting ration currency or stealing it from local boards to those engaged in the distribution of these illicit coupons. Also included have been dealers purchasing such coupons to cover up sales of rationed commodities without coupons and, in the field of gasoline, consumers who have obtained rations by fraudulent misrepresentation or who have purchased and used illicit coupons. . . .

"11,502 cases out of a total of 14,853 in which such action has been taken, have been handled by suspension proceedings. These figures reflect the considered judgment of OPA that by no other means can the diversion of scarce rationed commodities be prevented and the honest business man protected from dishonest competition.

"There is no doubt whatsoever that the federal courts would be unable to handle this mass of cases by criminal prosecution or by civil suit.

"The commissioners are appointed by the hearing administrator in the national office of OPA. The hearing administrator is responsible only to the administrator. Neither the commissioners nor the hearing administrator has any internal connection with any other department of OPA and a separation is rigidly maintained between them and the enforcement staff which investigates violations and presents the cases.

"On the point that they are employed by the same agency as is the enforcement department, it is interesting to note that 93.1% of all criminal prosecutions have resulted in convictions, 97.1 of all injunction suits have resulted in judgments for the Administrator, whereas only 86.6% of the suspension proceedings have resulted in suspension orders.

Right of Cross Examination

"The conduct of hearings before commissioners is covered by a procedural regulation which follows, except in those respects where it goes beyond, the recommendations of the Attorney General's Committee on Administrative Procedure in 1941. Hearings are open to the public, the respondent is entitled to counsel, to subpoena witnesses, to secure testimony and to the right of cross examination. A transcript of the hearing is kept and an appeal to the hearing administrator is a matter of right. Upon such appeal, an independent examination of the record is made by the hearing administrator.

"Pending the appeal, the respondent is entitled to a stay of the suspension order and, in fact, is granted a further stay pending his application for review by the courts.

"The charge is made that the administrative proceedings make no provision for judicial review. The fact is that these proceedings, like the proceedings before the Interstate Commerce Commission, Federal Trade Commission, Securities and Exchange Commission, and all other federal administrative agencies, are subject, as a matter of right, under the Judicial Code, to direct review by the United States District Courts in injunctive proceedings. In such injunction suit the court reviews the record to determine whether the findings are sustained by evidence, whether the proceedings have been conducted fairly and in accordance with procedural regulations, and whether the order of the Commissioner is arbitrary."

PIPELINES—*Views of the Industry's Problems a*

Washington— *Oil Talks Reveal Britain's Surrender of Cartel Idea* —By Herbert Yocom

WASHINGTON — Apparent willingness on the part of the British, as evidenced in the current oil talks, to withdraw somewhat from their historic participation in restrictive cartels is made the more understandable by Monday night's address of the British ambassador to the Charleston, W. Va., chamber of commerce.

Mr. Yocom

Lord Halifax paints a picture of an England firmly convinced that if it is to survive at all in the postwar era it can expect to do so only on the basis of an expanding world economy, one in which men no longer look upon trade "as though it were a loaf of bread which had to be divided among a number of people; so that if one got more than his fair share, someone else would have to take less."

"We know," said Halifax, "that trade is not, and never was, a fixed quantity; that, on the contrary, it is capable, according to the wisdom or unwisdom with which we all handle it, of almost indefinite expansion or contraction. There are great markets the world over waiting to be developed, if we can solve the problem of marrying consumer capacity to production power."

Then, in general terms, he outlines as follows "the sort of things that we (the British, the United States and other nations) shall need to do, if we are to be successful" in attaining that expanding world economy which is the "implied" aim of the Atlantic Charter and the declared objective of the Mutual Aid Agreement:

"We shall have to widen the channels of trade and lower, so far as we may, the barriers in the path of commerce. We must try to assure to all producers a fair and steady price for what they have to sell. We must try to prevent the disastrous cycles of booms and slumps, which means that, along with the development of the capacity of producers, we must develop the capacity of the consumers in order to provide stable, as well as expanding, markets."

PAW Backs Explorers

PAW is about to take an appeal to Economic Stabilizer Vinson as a result of the internal revenue bureau's refusal to allow petroleum operators the election of whether they will capitalize or charge to expense certain geological and geophysical costs incidet to exploration activities. Production Director D. R. Knowlton sums up the PAW case this way:

"In his price increase denial letter of Oct. 29, 1943, Judge Vinson directed the Petroleum Administration to formulate a program to provide every financial incentive short of a general price increase to assist and encourage the industry to stimulate exploration for new oil fields. We are appealing to Judge Vinson because we believe that the action of the Bureau of Internal Revenue is directly opposed to the purpose and necessity of stimulating exploratory operations, as recognized by the director of economic stabilization."

Showdown on Royalties

A showdown in the long effort to bring about a reduction in royalty payments on public lands is now at hand.

The matter is being brought to a head by PAW's production division, which has drawn up a preliminary draft of a proposed plan to limit payments to 12½% for prospective new development. Next step will be to seek the concurrence of the Geological Survey, after which a recommendation will be made to Secretary Ickes.

A Bouquet for Industry

When newsmen met with Mr. Ickes and other top officials this week for a discussion of the 100-octane program, they heard the PAW boss pay this fine tribute to the American oil industry: "The billion dollar construction program does not sound so large, perhaps, in comparison with the Navy Department's 1945 appropriation of about 35 billion dollars, but it is a tidy sum nevertheless.

"It has been spent for fixed manufacturing facilities, and three-quarters of it represents private capital—the investment of the petroleum companies themselves—and thus a living pledge of their faith in themselves and in the rest of us."

Atlantic Coast— *High Cabaret Taxes Cut Taxi Business 50%* —By Warren C. Platt

NEW YORK—It has often been said by those "from the sticks" that this town is the most provincial in the country. It certainly thinks only of itself, its personal pleasures and always of its own personal profit. Right now, even though it has gone through several years of war blackout, now ended, the town does not seem to know there is a war, nor that war needs manpower and gasoline.

Mr. Platt

The great complaint here today is that the new federal tax of 30% on liquor, food, cover charge and entertainment at cabarets and such establishments is killing that business. According to a guild of cabaret joint actors more than 8000 of them have been thrown out of employment the first month of the new tax, "hundreds" of places "catering to the poor man's entertainment, charging prices well within the reach of men in uniform and the laboring man" have closed down because the customers won't pay the 30% tax. As an example, one modest (?) establishment is reported to have suffered a drop in its gross sales of from $120,000 to $62,000 a month. Finally, it is reported in this morning's most reliable *New York Times,* that the taxicab drivers say their business has dropped off 50%.

Out over the rest of the country where munitions of war are being made in great quantities we hear that manufacturers are short of manpower while from Washington come cries for more men in the Army and Navy even though the war munition makers must cut down their output. Also, out over the rest of the country, we hear there is a shortage of gasoline that makes it necessary for the ordinary patriotic citizen with only "A" coupons, to walk a bit further while he uses his two gallons of motor fuel a week for still more essential purposes. We also, out Cleveland way, have heard complaint about this federal cabaret tax but nowhere near the lamentations of New York.

The lamentations of these New York joint owners and their "cafe society" might be taken by some cynical, but otherwise rather patriotic Americans, as evidence of a tremendous waste in motor fuel, manpower, food, alcohol and money—all of which are needed in the war effort if the authorities at Washington are to be believed.

Such a cynic might also observe that if this 30% tax does all this conserving for the war, maybe Congress should double the tax and close up all these admittedly pleasure joints, not only in this town but all over the country.

Maybe it is highly patriotic to get the

men in uniform tight, but we wonder just how patriotic it is to use up 50% of New York's taxicab quota of gasoline, as alleged, all that alcohol that is so needed in explosives, that food and that manpower, in order to get the man in uniform so mellowed that these folks and "little old New York" can make more profit out of his $50 a month pay?

But, of course, it is not the man in uniform who has been supporting all these emporiums of food and joy. It is the patriot from New York itself, from the surrounding towns and many from far away who come to town anxious to join in these patriotic ceremonies in the cabarets.

About the only suggestion one might have to bring about conservation of these war supplies, including gasoline down here, would be that PAW Deputy Davies and OPA Ration Chief Houston, who are trying to make drops of fuel do the job of barrels, petition Congress for a doubling of the tax. New York—at least its cafe population and joy industry, might try withdrawing from the country and the war effort, but then, that would be all right. We could at least refuse to ship them gasoline and fuel oil.

No Share-Riding in Taxis

Not to keep New York "on the pan" any longer than is necessary, but here is another idiosyncrasy that is, so far as we have heard, absolutely exclusive to it. This is the one town in the country that does not have share-riding of taxicabs. In fact this town prohibits it and the cops are vigorous in enforcing the city ordinance prohibiting it.

The reason for this official waste of gasoline? You can't trust the residents of New York in a cab with strangers, either the strangers or the residents are liable to lose watch, pocketbook, or clothes, while the ladies get slugged and worse.

The other week PAW District 1 Director Dodge, discovered this waste of gasoline and started out to get the law on New York for it.

Mr. Dodge, a hardworking boy from Texas and other points west, as well as from Bronxville, got off a long train at Grand Central with two heavy bags, from a far western trip. The Red Caps were all busy or gone so he lugged them up the ramp, through the station, to the street and finally up Lexington ave. for several blocks hailing cabs with one or two passengers, but they all went sailing by. The official conserver of gasoline in these parts, finally got an empty cab and went home. The next day he had Marketing Director Harper take the matter up with the police commissioner. Speaking in Mr. Ickes' all powerful name, Mr. Harper said New York would have to get in line with the rest of the country or Mr. Ickes would do something about it.

It appeared that the police commissioner would like to do something about it, too, not just to save gasoline but to reduce the depredations of the crooks but, he informed Mr. Ickes' able deputy, he just could not think of permitting cabs to pick up extra passengers because they are having more trouble than they can handle now with taxicab robberies and maulings. In fact, the situation is so bad that the police commissioner will not let a friend stop a cab that he is already in to pick up another friend, also waiting for a cab, lest they not be friends and something untoward happen.

Maybe New Yorkers should be combed over and some shipped out to these Jap concentration camps. But still, the Japs might object.

Midwest— *Interpretation of PDO 1 Phraseology urged* —By Earl Lamm

CHICAGO—There is a most urgent need for an interpretation of the phraseology of PDO 1 for benefit of the industry at large, which does not understand it.

A member of the Dist. 2 D. & M. committee told this correspondent that he had talked with many jobbers over his state and elsewhere "and only one out of ten had ever heard of the proposed order and that one didn't understand it." Perhaps it's not that bad, but under present conditions, it is not surprising that the Michigan Petroleum Assn. at its spring convention in Detroit last week produced a resolution of biting criticism, which, it is understood, was wired to Francis Biddle, U. S. attorney general, with request that he stop issuance of the order on the basis that it would force illegal discrimination upon jobbers by compelling them to decide which of their customers is essential under paragraph C-2-II. (*See story, p. 36*).

Mr. Lamm

This occurred despite PAW Hochuli's repeated statement that the order was designed for the specific benefit of jobbers, and as apparently proven later at the D. & M. committee conclave, April 26, when the predominant major company members of the committee are said to have voted unanimously against the order and the two independent members voted for it. Similar stand was reported taken by Dist. 1 marketing committee in New York.

This evident lack of understanding of the order by the industry generally prevails regardless of the fact that NPN and OILGRAM have published the full text of two or three drafts of the order against the wishes of both PAW and the industry committees, whose closed door policy definitely did not succeed in keeping down industry confusion over the situation and the D. & M. vote threw Mr. Hochuli temporarily into a fog. It has caused many oil men to sigh: "Guess we'll have to take what the doctor orders whether or not we understand it or like it."

Two highly important chapters are missing from the situation: Operators in areas of ample supply doubt that there is a shortage elsewhere. If there are important shortages, where are they? Name the state, the county, the town. It is recognized that shortages shift from time to time, but where were they on what dates? PAW should supply this information. Missing chapter No. 2 is details of thought as to how PDO 1 (and any other government order) was boiled down to its final form.

PDO 1 is supposedly the concentrated essence of fair allocation oozing from the most potent brains of the industry over a period of six to nine months, which has been arbitrarily dumped in a single lump on the minds of we lesser mortals. On that factual premise, how can non-committee members, who have never read nor heard it explained, be expected to understand it?

Perhaps we are expected to say here that if the trade press were admitted to committee meetings everything would be lovely. The facts are that as long as restrictive regulations are issued and there is still a live spark of freedom in the breast of any oil man, that Utopia will never exist. But it can be stated just as truthfully that if the industry as a whole is allowed by whatever means possible to follow the development from beginning to solution of any clearly and concisely stated problem, the conflict of opinion upon application of an order properly arrived at will be at minimum. Under such circumstances, the few men responsible for issuance of such an order could point to the public record and tell anyone who does not understand it that it is his own fault.

While PDO 1 is being polished up for issuance, the supply order to play the bass notes on the allocation piano is being tuned up under similar mysterious circumstances. The problem of primary supplier pooling of products has been declared ten times as difficult as PDO 1, and it was asserted last week that the newest draft of the order reads like a postwar project. Its ten pages are long and about nine and one-half pages are consumed with administrative instruction, while the remaining half page is devoted to formula for the direct problem of allocation.

Independents' Council Supports PDO 1 and 'Indiana Plan'

NPN News Bureau

CHICAGO — National Council of Independent Petroleum Assns. at its meeting in Sherman Hotel here April 26-27, approved PDO 1, subject to minor charges that were developed during the Dist. 2 Distribution & Marketing Committee meeting on Wednesday, which the members attended upon invitation of D & M Chairman Majewski.

At the Thursday morning meeting of the council, Shad Polier, OPA enforcement director, demonstrated OPA's methods of detecting counterfeit gasoline rationing coupons and tracing them to their source. He then explained the "Houston Plan" for industry co-operation in the enforcement program, which has been evolved out of the "Indiana Plan" initiated in that state by the industry, Individually Branded Petroleum Marketers, Indiana Independent Petroleum Associations and the district office of OPA. (*See NPN, April 26, p. 3*).

The "Houston Plan" was also approved by the council after discussion, with the understanding that it would be carried out in the spirit in which it was explained by Mr. Polier by appointment of industry committees to screen minor complaints within legal limits, without trespassing upon anti-trust questions.

Mr. Polier then launched upon a strong defense of the present OPA hearing commissioner system during which he criticized Warren C. Platt, editor of NATIONAL PETROLEUM NEWS, for calling OPA hearings "kangaroo courts".

NPN Hit and Defended

Harry B. Hilts, secretary of the Empire State Petroleum Assn., who was present, informed Mr. Polier that the term "kangaroo courts" was first applied by the defense to the OPA setup in connection with the Petrol rationing violation case in New York State. Mr. Polier charged Editor Platt with publishing in an October, 1943, issue of NPN a misleading report on a case in Nebraska. Herb H. Hahn, secretary of Nebraska Petroleum Marketers, Inc., arose and told Mr. Polier that he was one of three men in Nebraska who sat through the case referred to, then prepared and sent the statement to NPN. The report, Mr. Hahn said, was based upon the fact that the OPA hearing commissioner judging the case did not know anything about the oil business and did not understand its operation.

Mr. Polier endeavored to point out that federal district courts would be so flooded with work that they would be unable to handle all ration complaints—in fact, would not have accepted anything like all of the 11,000 or more cases that have been brought by OPA to date. He invited council members to suggest a better system than the present OPA procedure. He said that OPA hearing commissioners had to pass Civil Service examinations before they were appointed by OPA and that they constituted a separate department entirely and do not come under his direction as head of the enforcement branch. He said, however, that they were hired and could be fired by Chester Bowles, OPA administrator. Their appointment by OPA, Mr. Polier said, was similar to the appointment of federel judges, although it was not brought out until later in the meeting that federal judges are appointed for life and are not subject to removal from office except for misconduct, malfeasance, etc.—in principle, untouched by politics.

Mr. Polier also failed to mention the instances where OPA hearing commissioners have in effect deputized attorneys in the regional OPA office to act as hearing commissioners. The deputy's report in such cases is subject to the hearing commissioner's review and approval, but last year, OPA Region 6 Hearing Commissioner McFarland announced in the local press that more than 200 attorneys at his invitation had volunteered to act as his assistants.

An Open Letter to Chairman Lea

Hon. Clarence F. Lea
Lea Oil Investigating Committee
Washington, D. C.

Dear Mr. Congressman:

In reference to some remarks in the record of your committee of April 21 made in regard to NATIONAL PETROLEUM NEWS and the writer by Mr. Shad Polier of OPA.

First, we have never refused to print corrections of any misstatements of ours in regard to Mr. Polier, OPA or any one else. What Mr. Polier probably refers to is that we once refused to change our true statements about OPA enforcement to false ones.

Two, the editorial that Congressman Brown put in your record to which Mr. Polier took exception, is but one of a hundred and more editorials and articles that we have printed since the start of OPA in an effort to get that outfit to give at least a slight obeisance to the law. We believe we are entirely warranted in pointing to some excellent results that are much to the benefit of the oil industry, the people and the country's war effort even though our editorial campaign, as well as the results, were much disliked by various OPA members including Mr. Polier.

NPN points with great pride to its part in the campaign in the fall of 1942, of the independent oil men of the country which brought about the discharge of Leon Henderson. NPN contributed six and eight pages of editorial and analytical facts every week to that campaign. That this material and this campaign was not to the liking of the OPA boys is shown by the fact that they sicked the FBI on the protestants and felt so certain of the success of this gestapo act that the Office of War Information announced that we were all to be arrested in a few days.

After these announcements, on and about Thanksgiving Day 1942, you may recall, almost a score of members of the House took the floor and so blasted Henderson and his Hitlerian concepts that the President shortly afterward fired him.

Since then NPN has continued its criticisms of OPA acts and at the same time has approved and co-operated with Henderson's successors who NPN knows are making great improvements in the organization.

But, however great those improvements, NPN editorially has urged that Congress should reorganize OPA and put all of its activities in a statute including its "kangaroo courts". All the improvements for which NPN has been contending, we believe, have been brought to your attention by many witnesses including men from the oil industry. However, should you desire to study our suggestions and comments, we shall be glad to make you up a portfolio of them.

As to Mr. Polier's criticisms, if he would but read with care and thought and an open mind all of our editorials and articles on OPA, instead of but one, we are sure he will be able to see more clearly some of the terrible errors of the past and be better able whole-heartedly to co-operate with his present superiors who are doing such an excellent job in reforming this monstrosity of bad law.

WARREN C. PLATT

Rites Held for F. J. Twogood

NPN News Bureau

NEW YORK—Funeral services were held here May 2 for Frederick J. Twogood, for many years general manager of the Standard-Vacuum Oil Co., at Shanghai, China. He was 54.

Mr. Twogood, one of the most prominent American businessmen in the Far East prior to the war, was imprisoned by the Japanese in Shanghai where he spent 109 days of incredible hardship and privation. He was repatriated on the S. S. Gripsholm in August, 1942.

Sylvestre, Royal Director, Dies

NPN News Bureau

NEW YORK—Francis R. Sylvestre, 50, former president of Royal Petroleum Co., died here on April 29. He formerly headed the Sylvestre Oil Co., a marketing firm in Mt. Vernon, N. Y., and had organized other companies in this country and Canada. He was a director of Royal at the time of his death.

Oil Man Leads Defiance of New Deal's Labor Pact; All Industry Should Applaud His Courage!

THE OIL INDUSTRY participated in, perhaps even helped start, one of the two great battles for civic freedom fought by citizens in this country last week.

Just after the Army, without order of any court, had carried the president of Montgomery Ward out of his private office and off the premises of his company, thus "seizing" for another department of government a private and non-war business, the industry members of the War Labor Board, led by an oil man, finally stood their ground against the threats and intimidations of the other members of the board and demanded court review of that board's "maintenance of membership" clause in contracts with labor unions.

Tossing the aged big business man out on the street because he refused to adopt that same maintenance of membership clause in a contract with a union he no longer thinks represents his employes was the more spectacular but the almost simultaneous assertion in the public of their individual opposition to this same clause by the industry members of the labor board can undoubtedly be described as of greater fundamental importance, because it represents more public rebellion of public officials who have thought contrary to the New Deal's pet ideas but would not speak or vote that way. However, it must be admitted that the dramatic rebellion of President Avery, of Montgomery Ward, and the Hitler-like physical assault on him ordered by the head of the Department of Justice, aroused such a blast of condemnation of the government's undemocratic method, as to make it possible for real reform to come from the protest of the minority industry members of the War Labor Board.

It may also be pointed out that contributing to the open exhibition of moral courage by these industry members, and which at least made it easier for Mr. Avery to take the position he did against the Hitlers of Washington, is the fact that the oil industry, particularly the Independents through their many associations, has been openly and vigorously contending during these war years, against the illegal, unfair, dictator-like and stupid acts and regulations some of these Washington agencies have sought to impose on the industry and on the consuming public. When few outside their ranks have raised a voice in support of these Independents making a public fight against injustice, and when the reformers at Washington have bellowed loudly and even called out their Gestapo and denounced these Independent oil men as "Nazi's", these Independent oil men have continued to carry on the fight for real liberty and constitutional law in this country. The successful fight these oil men made on Leon Henderson a year ago last winter, made it easier for the fighters for liberty this last week to put on their own rebellions.

The oil man who seems to have led last week's fight for freedom in the War Labor Board is James Tanham, a director of The Texas Co. and long a member of the War Labor Board. The decision he and his industry associates made was in connection with the review of the case of the C. I. O. Oil Workers Union which appealed from a decision of the regional board in Texas which had refused to impose the maintenance of membership clause on the Humble Oil & Refining Co. in connection with a labor dispute at its Ingleside plant.

The *New York Times* says that Mr. Tanham first wrote a vigorous dissent from the board's decision to over-rule the Dallas board and give the disputed clause to the Oil Workers whereupon Chairman Davis, of the Labor Board, told Tanham that if he disagreed and the board stood divided one of them would have to resign. Tanham then is reported to have toned down his dissent. However, what was finally issued by the minority seems quite vigorous and to the point. (*See Page* 7).

Chairman Davis' efforts to cow the industry members did not reach the form of a written statement but there was issued the remarks of a "public" member, a Dr. Graham, who stormed away with much noise and, we would say, considerable mis-interpretation. According to Dr. Graham, and it was the same argument presented by Chairman Davis in a statement in regard to the Montgomery Ward case, while no one else can do anything that will retard our war effort it is perfectly all right and quite lawful for the labor unions to strike and to threaten to strike in order to achieve their every demands. Graham said that "an answer had to be found" in the old "open" and "closed" shop dispute else labor would strike and hinder our war effort, so Graham argued the thing to do is to give labor unions what they want and that whoever is opposed to such surrender to the unions' bullying is not patriotic. In short, Graham says to surrender to evil and injustice, a principle that certainly was not recognized by the founders of this country.

The merit of the argument in the War Labor Board and for opposing which President Avery was thrown off his premises by armed trespassers, NPN imagines it is needless to discuss with oil men. Certainly, the "maintenance of membership" clause formulated by the Administration and the way in which it is applied, is a direct violation of the rights of Americans, in that they either have to belong to the unions and pay the dues, or they cannot work, not even at government jobs.

But of more importance to oil men and to all citizens than that this un-American clause may finally get an airing, even though only before New Deal Courts, is the fact that the industry members on the Board finally got up their courage and voted an opinion contrary to the vociferous majority, and that the public mind has advanced so far against Washington's dictatorial tactics, that even though the greatest war of all history is on, the public and Congress, for the most part, are loudly cheering the spunk of President Avery for standing on his rights.

The average person who does not have much opportunity to get the inside gossip from Washington, nor the time to study all the documents and stunts pulled by New Deal leaders, does not realize the lengths to which these inside New Dealers go to gain their ends and to maintain dominance over all government machinery. These insiders are constantly on the alert to further their own ideas. They seldom overlook any opportunities. They are eternally at every individual in government service who is outside of their ranks. They argue without limit, they do not bother with the truth, they bully and intimidate ruthlessly and they do not hesitate to use all the powers of government they can lay their hands on, to force their victims to obey, just as these New Deal leaders called out the FBI to be the gestapo to intimidate the Independent oil men who were fighting some of Hendersons's foolish orders and just as the chief law officer of the country, called on the army to do a police job in laying violent hands on a private citizen without a warrant or court order.

Business men in government service need to be constantly encouraged when they do right and they need to be supplied

READERS' comments and opinions will be much appreciated by Warren C. Platt, NPN's Editor and Publisher, Penton Building, Cleveland 13, Ohio.

with facts and arguments against the falsehoods and specious arguments given them by the inside reformers.

Late as it was, it was highly courageous and patriotic for Oilman Tanham and his industry member associates finally to voice in public contrary opinion to the domineering and noisy majority, an opinion contrary to the pet policy of the Administration, and an opinion that may lead to the upset of the political trade that the New Deal has made with the union professionals, an upset that can have a most important effect on what happens next fall.

Every oil man should make it his personal duty to see that his brother oil men who are doing a good job for country and industry in Washington and elsewhere, do not feel lost and overlooked. White them a letter with a pat on the back, when they deserve it.

OWI Using Industry's Conservation Drive To Duck Oil Shortage Responsibility

IT SEEMS that there is, and then on the other hand there isn't, an oil shortage.

Then, it seems that "there was only a net loss of 18,000,000 bbls. in crude reserves at the end of 1943" and so "what are reserves for unless to use in days like these?"

But it also seems the gasoline problem is "increasing in severity," that since 1938 "we have used our oil faster than we have found new oil" so there is "no alternative but to use" it "sparingly." "Restrictions are unlikely to become easier" and "the situation is serious—far more serious than most Americans realize. . . No one has found a solution." Importing much oil, plus increasing our reserves "may alleviate the situation, but they are unlikely to affect a cure."

But there is "no shortage."

On the "no shortage" side is Economic Stabilizer Vinson, who so testified before the Senate Banking Committee last week. On the "yes, there is a shortage" side and "nothing much can be done about it," is the OWI and the special committee of advertising men appointed by PIWC to formulate a "yes there is a shortage" advertising campaign to educate the public on how to conserve oil.

Then on a third corner of the argument is a large part of the oil industry, including PIWC itself, PAW and all producers associations, who disagree with the special committee of oil advertising men and OWI, and who say that a higher price for crude oil stands a good chance of getting still more rigs running to find more oil to relieve the present severe shortage.

The Economic Stabilizer, from the White House, of course, is doing his best to "hold the line" so he is most complacent that there are going to be more wells drilled this year than last, even though they may not find the oil when 100 or 500 more might. He announces that the administration is not going to allow any more equipment for drilling than enough to put down the present schedule of wells, regardless of how short the supply of oil gets because, he argues, if enough oil cannot be found with that equipment then it cannot be found.

On the other hand, OWI and this special advertising committee of PIWC are urging the oil industry to undertake, by individual companies, a big campaign to tell the public how short oil is. The slogan recommended for the advertising is "Gasoline Powers the Attack—Save Every Drop." The committee is sending to publishers, radio broadcasting stations, advertising agencies and oil companies a large portfolio of suggestions for advertising copy together with a 30-page document which undertakes to "explain the facts about gasoline." It is signed by OWI, and is marked "in collaboration with PAW, OPA and ODT"; but the portfolio of the oil industry's advertising committee also publicly claims credit for its creation.

In distributing and standing sponsor for this particular document oil companies may be getting themselves into an embarrassing position because the document carefully refrains from saying a single thing to show what the oil industry has done, or tried to get done, first to avoid this oil shortage and now to alleviate it. The document is purely the White House's position on the oil shortage, or it was before Vinson spoke last week. Certainly, it is not the position as stated so many times by PAW, PIWC or any of the numerous oil industry organizations that have been trying to get the national administration to realize the seriousness of the shortage and to do that which is the only thing that can be done to increase our oil supply—put whatever number of rigs may be necessary at work drilling for oil by establishing a fair price for crude oil finding and production.

While the oil companies need not get into an open fight in the advertising pages with the White House over the latter's decidedly negative oil supply policy, nevertheless the oil industry should not rush wildly out before the public, crying loudly about an oil shortage, as if the industry had just waked up to the situation and had done nothing about it and knew of nothing to do. Yet the recommendations of this advertising committee, coupled with the most incomplete and limited statements of fact, as per OWI handiwork, and some are quite unfair, would have the oil companies standing helpless and weeping before their customers, silent as to all that they have been trying to do to protect those customers and the country with sufficient oil supply.

Obviously any such spectacle would prompt some of the customers at least to say, "Well, you are in the oil business, why haven't you done something about it? Why not do something now instead of standing there wringing your hands in anguish?"

The industry will never be able to catch up with these questions, as the politicians at Washington and elsewhere will seize on the industry's silence to do still more than they are trying to do, to "remedy the situation".

Please note that their "remedies" so far are for the government to build a pipe line in Arabia, perhaps to finance more refineries there, to finance a refinery in Mexico, to expand the Army's Canol project in Canada and Alaska, to develop the Navy's oil reserves at Point Barrow, Alaska and to proceed more rapidly with the expenditure of $30,000,000 for Ickes' Bureau of Mines to build "commercial-size pilot plants" for retorting motor fuel from coal.

Also do not forget Brother Ickes' latest scheme, announced recently, of putting all the war plants, including refineries, tankers, oil pipe lines etc., into vast companies and issuing the stock to the returning service men as a bonus.

It is clearly up to the industry to do whatever is necessary, including using advertising, to educate itself and the general public to a vast program of oil law compliance. Such an educational effort is direly needed and probably only through such an effort can a better degree of compliance be had from the American public.

But certainly the industry should not leave itself wide open to the charge that it has been negligent to its customers and the country in its responsibility to try to get still more oil as it has been needed. It is not necessary for the industry to fight, in its educational advertising, the battle of how to get more crude, but the least the industry can do is to enter a simple but definite disclaimer for responsibility for the present deplorable and at least largely unnecessarily severe shortage. The industry should not let OWI and the White House use the industry's good money and advertising space to sell to the public the administration's alibi for grossly and unpatriotically mishandling the oil supply.

When rapid-firing guns get hot, they get thirsty. If they get too dry, they're likely to freeze, jam up.

That's where the can comes in. It carries oil—all kinds of fine lubricants that protect delicate mechanisms. Not only guns, but planes, tanks, jeeps.

Which brings us to your next new car. New and better oils will be needed to guard its operation. If we know the oil industry, they'll be ready. And you'll get these oils in refinery-sealed cans—the exact grades and brands you want, completely protected.

Many things will soon be back in cans—beer, coffee, shortening. There'll be new things in cans, too. As war is proving, the tin can is the best all-around container . . . strong, safe, convenient.

We're doing a lot of research today. Not just on cans, but on products. Many of our discoveries for war someday will be mobilized for peace . . . so that in the years to come you'll enjoy *new and better things in Continental cans.*

NOTE TO MANUFACTURERS: We will be glad to discuss future uses or improvements of your product or package, and to help you in post-war planning. Write to our Post-War Planning Department, 100 East 42nd Street, New York City 17, N.Y. or Continental Can Company of Canada, Limited, Montreal.

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ARMY E NAVY

Co-ops' Free Tax Ride Draws Fire of National Tax Equality Assn.

Private Business Profits Help Finance War While Rivals Expand And Build Up Big Postwar Funds, Organization Charges

By Earl Lamm
NPN Staff Writer

CHICAGO—With the great rise in income taxes since the start of the war, independent oil men, as well as larger oil companies, have been complaining more and more about the competition with co-operative oil companies, who, it seems, pay no income taxes, or relatively small amounts, if they are properly organized under the co-operative laws.

Independent and privately owned oil businesses, whether operating as corporations or proprietorships, now find themselves under a handicap in their competition with the co-ops, by reason of having to pay upwards of 40% and even a possible 80% of what can be small net earnings to the government, while their co-operative competitors can put this 40% to 80% into reserve funds. From all reports, that is what most co-operatives are doing these days instead of "returning savings to their membership" as profits and patronage are officially designated in co-operative practice.

With these rapidly growing reserve funds, the co-operatives are expanding as much as they can under present conditions; but particularly with these profit funds, they will be able to put on aggressive programs of rehabilitation just as soon as new equipment is available and all restrictions are removed from the volume of petroleum products which they can buy and sell.

Handicaps to Independents

But the independent oil company that has paid a large percentage of even small earnings to the government to help pay the war expense, considers itself handicapped just that much in its competition with its government-favored competitors, who can buy new equipment when the independent can not.

With the weight of this unequal tax burden threatened to be thrown farther and farther out of balance by pyramiding government war expenses on the one hand and the rapid growth of the tax exempt co-ops on the other it is pertinent to inquire:

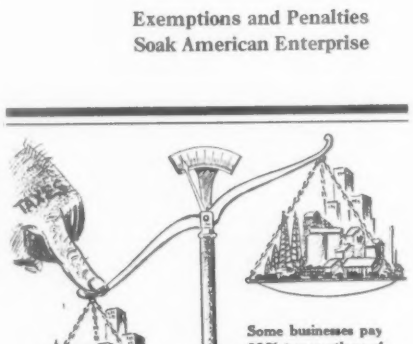
Who, when, where, how and why was the National Tax Equality Assn. Inc. organized, although a part of the answer is inherent in the name. The questions were put to Loring A. Schuler, general manager of the association, which maintains offices at 231 South La Salle St., Chicago.

Objectives Outlined

"Look these over," he said, "and if you have any more questions, ask them."

Among the mimeographed and printed letters, bulletins and leaflets he supplied, was a sheet showing the association was incorporated in the state of Illinois, Oct. 11, 1943, by Ben C. McCabe, Homer D. Jones and J. L. Welsh. The application for incorporation stated:

> "The object of the corporation shall be to conduct educational, scientific and research activities relative to disparities in Federal and state tax statutes and other laws and regulations affecting business, and to disseminate such information to civic organizations and representatives of business affected thereby, to the public and to Federal and state governments. The corporation shall be non-sectarian, non-partisan, and no part of the net earnings, if any, of the corporation shall inure to the benefit of any private shareholder or individual."


Tax Inequality
Will Destroy
Private Business
Exemptions and Penalties
Soak American Enterprise
Some businesses pay 80% taxes: others of the same kind get off scot free. Why?
National Tax Equality Association
231 South La Salle Street
CHICAGO 4, ILLINOIS
NTEA 9-1-5-1-44

Cover of a typical pamphlet issued by the National Tax Equality Assn.

A list of the officers shows B. C. McCabe as president and treasurer. He is also president of International Elevator Co., Minneapolis, Minn. P. F. Scheunemann, chairman, tax committee, American Retail Coal Dealers Assn., Minneapolis, is also secretary of N. T. E. A. There are two vice presidents—G. W. La Pointe, Jr., president, O. & N. Lumber Co., Menomonie, Wis., and Vernon Scott, counsel for the Ohio and Indiana State Chambers of Commerce.

On the board of directors representing petroleum, is Harry B. Hilts, secretary, Empire State Petroleum Assn., and an independent oil jobber in New York. Other directors represent various industries and companies in different parts of the country. Their locations apparently indicate a trend toward the influence of small business, although McCabe's International Elevator Co. is rated by Dun & Bradstreet as AAA-1—that is, over a million dollars.

Asked for a statement of facts covering the tax exemption of co-operatives and other businesses on which they base charges of inequality, Mr. Schuler thumbed a copy of the "Bureau of Internal Revenue income tax regulation 111," which was lying on his desk. It's a volume about 6 x 9 in. and about two inches thick. Page 313 is headed: "Subpart C, supplemental provisions, supplement A—rates of tax, Sec. 101."

On page 323 under this Sec. 101, is found the following: "(Sec. 101. Exemptions from tax on corporations—as amended by Sec. 217(a), REV. Act. 1939; Secs. 137 (a), REV. Act 1942).

Organizations Exempted

"(The following organizations shall be exempt from taxation under this chapter—).

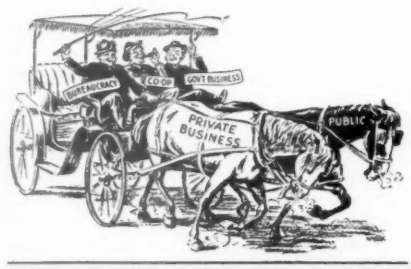
"(12) Farmers', fruit growers', or like associations organized and operated on a co-operative basis (a) for the purpose of marketing the products of members or other producers, and turning back to them the proceeds of sales, less the necessary marketing expenses, on the basis of either the quantity or the value of the products furnished by them, or (b) for the purpose of purchasing supplies and equipment for the use of members or other persons and turning over such supplies and equipment to them at actual cost, plus necessary expenses. Exemption shall not be denied any such association because it has capital stock, if the dividend rate of such stock is fixed at not to exceed the legal rate of interest in the state of incorporation or 8 percentum per annum, whichever is greater, on the value of the consideration for which the stock was issued and if substantially all such stock (other than non-voting preferred stock, the owners of which are not entitled or permitted to participate, directly or indirectly, in the profits of the association, upon dissolution or otherwise, beyond the fixed dividends) is owned by producers who market their products or purchase their supplies and equipment through the association; nor shall exemption be denied any such association because there is accumulated and maintained by it a reserve required by state law or a reasonable reserve for any necessary purpose. Such an association may market the prod-

ucts of nonmembers in an amount the value of which does not exceed the value of products marketed for members, and may purchase supplies and equipment for nonmembers in an amount the value of which does not exceed the value of the purchases made for members, provided the value of the purchases made for persons who are neither members nor producers does not exceed 15 percentum of the value of all its purchases. Business done for the United States or any of its agencies shall be disregarded in determining the right to exemption under this paragraph;"

Extent of Exemptions

There follow detailed explanations of how the exemption is applied. While farmer-producer-consumer co-ops appear to be the most aggressive in the co-op movement, tax exemptions, or partial exemptions, are allowed many other businesses and organizations operating under the co-op principle or to which the co-operative idea applies to some degree including, according to other chapters of the same income tax manual, the following:

Labor, agricultural, and horticultural



"Who Gets the Free Ride?" was the question asked in this National Tax Equality Assn. cartoon

organizations, mutual savings banks, fraternal beneficiary societies, building and loan associations and co-operative banks, creamery companies, religious, charitable, scientific, literary, and educational organization and community chests; business leagues, chambers of commerce, real estate boards and boards of trade; civic leagues and local associations for employes; social clubs, local benevolent life insurance associations, mutual irrigation and telephone companies, and like organizations, corporations organized to finance crop operations; religious or apostolic associations or corporations, and voluntary employes beneficiary associations.

After completing a mental survey of this tax exempted list, Mr. Schuler looked us in the eye from across his desk and declared emphatically: "One thing I want you to clearly understand is that we are not fighting the co-operatives or any other business, society, club or religious organization. It is not our purpose to object to any form of business, social or religious organizations may take. Our entire effort will be directed merely toward an equalization of the presently unfair distribution of the tax burden. Activities of this association will be held toward that point."

Merely Assembles Facts

Apparently, Mr. Schuler is conservative and wants to stay in the background to avoid the wrong impression. He said no to a request for his photograph, and declared the association was not a promotion scheme in any sense, merely seeking to assemble facts pertaining to the inequality of taxes and present them to businessmen, the public and government in an effort to secure tax equality.

Mr. Schuler is listed in "Who's Who in America" as a former editor of *Country Gentleman* and *Ladies Home Journal* from 1913 to 1927. During his editorship of *Country Gentleman* and later, he said he observed the growth of co-operatives. He came out of retirement in California to assume his present post with N. T. E. A.

He said voting membership dues in the association were a minimum of $50 a year and non-voting membership, any lesser amount, and that upon payment of dues, membership was extended to individuals, companies and organizations having a genuine interest in the association's problem. There are now 12 employes on the association's staff.

The association sums up the co-op tax inequality in one of its folders. This points out that while private business had no objection to the earlier connection of co-operatives which was concerned only with helping the farmer market his products and to buy supplies at wholesale the original farm cooperatives have branched out and grown to great size in fields far removed from their original objective.

They have entered the fields of manufacturing, milling, oil drilling and refining, printing, and they also operate grain elevators, food stores, coal yards, lumber mills and packing houses. "They boldly predict that they will soon enter every sort of business—and that 'when the people deal only with themselves' they will wipe out salesmen and all middlemen," the circular says, adding that all these ventures enjoy income tax exemption and other advantages denied to private business.

"Pursuing these advantages with vigor," reads another statement, "farmer co-operatives have grown into 'big business', with stated objectives by some of their spokesmen of continuing to expand until there is complete elimination of intermediate charges and profits and a building of 'a different social order'. In 1942, according to figures compiled by the Farm Credit Administration, a $2,840,000,000 volume of business was done by 10,550 farmer marketing and purchasing co-operatives."

Tax Comparisons Given

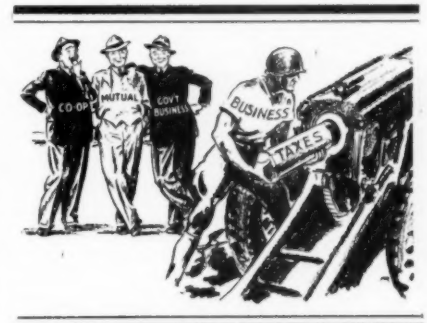
Striking at the difference between tax exempt co-operatives and private business, a printed leaflet asks this question: "Who gets the free tax ride?" This comparison is then cited:

"Earnings for one year of a co-operative (From consolidated operating statement of Farmers Union Grain Terminal Assn. showing "savings" for year ending May 31, 1943)	$1,199,000
Federal income taxes paid	none
Net earnings for dividends, expansion, reserves, etc.	$1,199,000

An this is the way private business would have to show similar earnings:

Earnings for one year of private business	$1,199,000
Federal corporation income, capital stock and excess profits taxes (Estimated by present Federal tax schedules on earnings like those of the co-operative example)	875,000
Net earnings for dividends, expansion, reserves, etc.	$ 324,000"

As to the extent of activity by N. T. E. A., bulletin No. 10 sent to members April 15, states that distribution of the association's leaflets is nearing the half-million mark, with constantly increasing demands coming from all parts of the country. "The mailing list has grown to more than a thousand names within the past month. Meetings with



Another National Tax Equality Assn. cartoon pointing up unfairness to private business of tax exemption enjoyed by some groups

groups of interested business men are scheduled for all parts of the United States."

Co-op Publications Stirred

Result of this wakefulness has been a very apparent stirring of the opposition as given in quotations by N. T. E. A. from co-operative publications, and as a result of a joint meeting held in Washington, March 10, by representatives of the co-operatives and N. T. E. A. under the sponsorship of the U. S. Chamber of Commerce.

This meeting was arranged, N. T. E. A. says, when the U. S. Chamber of Commerce and the National Assn. of Manufacturers expressed concern over the possibility that the Tax Equality group's effort might have an upsetting influence on good agriculture-business relations.

A private news agency later reported that as a result of the meeting N. T. E. A. intended to shift its efforts to a drive for reduction of corporation income taxes

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MINNEAPOLIS, MINN.

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Omaha, Neb.

Petroleum:

HARRY B. HILTS, *Sec.*
Empire State Petroleum Assn.
New York, N. Y.

Retail Merchants:

MILTON CONE
Spotless Co.
Richmond, Va.

Organizations:

C. A. JACKSON, *Exec. Vice-Pres.*
Indiana Chamber of Commerce
Indianapolis, Ind.

Small Business Organizations:

F. A. VIRKUS, *Pres.*
Conf. of Small Business Org.
Chicago, Ill.

with the hope that the Co-op council would go along on such a plan. But this N. T. E. A. denies.

The fact is, according to Walter M. Evans, counsel and spokesman for N. T. E. A., that while D. L. James, of the U. S. Chamber who presided at the parley said he believed that the support of the various co-operatives for the Chamber's program of tax reduction could be obtained if the N. T. E. A. would end its campaign to obtain tax equality on the part of co-operatives, the N. T. E. A. made no commitments at the meeting.

Co-op delegates at the meeting, Mr. Evans said, revealed that they were not authorized to make any commitments but felt their groups would be willing to agree either to support postwar corporate tax reductions or at least not to oppose such reductions if N. T. E. A. would cease its efforts to require taxes on co-operatives.

Proposal Too Indefinite

But this was too indefinitte for N. T. E. A.

"Obviously," Mr. Evans said, "this would be a death sentence for the only national organization which has ever successfully challenged the statutory discriminations that give the co-operatives an almost overwhelming competitive and marketing advantage over private business.

"Nothing whatever was proposed at the meeeing which would be an acceptable substitute for the imperative demands of tax equality between all competing businesses," a N. T. E. A. report asserted, and the representatives who attended the Washington meeting recommended that the association's program "should be prosecuted vigorously to a successful conclusion."

Further examination of the N. T. E. A. literature reveals these quotes from co-op publications:

From an editorial in *Farmers' Elevator Guide* for March: ". . . . It seems to us that the less dangerous, although it may be the more arduous path is, when and if income taxes come, as they surely will by next year unless the Congress has a mighty change of heart, for co-operatives to take up the burden manfully, sharing their meager savings with the government through the difficult years of postwar reconstruction. If it is right, and we believe it is, that they be relieved of these taxes, that right will eventually be re-established . . . . It may be true in military strategy that 'the best defense is to attack' and we may have something to say at a later time about that. But so far as concerns the notion of anticipating savings so there will be no savings on which to pay taxes—we're agin it!"

Would Cut Prices

Other co-op spokesmen, however, have carried this thought further. An N. T. E. A. bulletin to members dated Feb. 7, says that after quoting from Vernon Scott's recent talk to trade and civic organization representatives at the Indiana State Chamber of Commerce, the *Indianapolis Star's* Maurice Early consulted a spokesman for the co-operatives affiliated with Indiana Farm Bureau for his answer.

"The spokesman declared," says N. E. T. A., "that 'Government does not dare subject the co-ops to income tax because they are non-profit organizations'. But 'should the movement succeed to subject them to Federal income tax, they merely would reduce selling prices so there would be no profit to tax'."

N. T. E. A. bulletin No. 7, dated Feb. 25, ends with this statement:

"*Business Week*, Jan. 22, 1944, reporting the fright of private enterprise because of the threat of the Consumers Co-operative Assn. of North Kansas City, Mo., to cut prices to members to assure them the 'savings' they now receive in patronage dividends and to erase the taxable earnings in case the co-ops are declared taxable:

" '. . . . the alternative of straight price-cutting operations is calculated to be even more odious to private business. If co-op profits are taxed, co-ops will abolish profits by cutting prices, and Cowden (head of Consumers Co-op) points out that, since they are non-profit institutions anyway, they would cut them to the bone, charging just enough to cover costs of doing business."

Your "Sacrifice"

Dear Customer:

You have given up a lot of things because of the war.

You can't do much driving. You can't buy tires like you used to. And the same goes for meat and butter and cars and electric iceboxes.

That's tough on you. You're "sacrificing"

Me, too. My gas business is down to a trickle. My tire business has practically folded up.

And on top of that, I'm short of help. That's why it sometimes takes me longer to serve you than it used to.

But I am more anxious than ever to inspect your tires and your battery. If anything, my lube jobs are more conscientious than before. That's my part in helping you *Care for your car for your country.*

I am working longer hours than any man should, and making less money than I did. So that's my "sacrifice".

But, brother, you and I are not making any sacrifice that even deserves to be mentioned in the same mouthful with the sacrifices of our fighting soldiers, sailors, and marines.

Phillips 66

Your Phillips 66 Serviceman

FOR VICTORY... Buy U. S. War Bonds and Stamps

➡ **THIS IS ONE** of a regular series of advertisements now appearing in 425 leading midwest newspapers on behalf of the Phillips Petroleum Company and its dealers.

*Peace, Plenty and Petroleum**

Private Enterprise 'Soundest Choice' to Develop World's Oil Resources, Harden Report Stated

By Dr. Benjamin T. Brooks

In December, 1943, the foreign oil committee of PAW made a report which was not released by the petroleum administrator presumably because the report strongly recommends that the foreign oil business be left strictly to private enterprise.

Platt's Oilgram scooped the report, however, and the industry's own P.I.W.C. demanded a showdown of the petroleum administrator.

The FOC was a committee of 12 headed by Orville Harden, a vice president of the Standard Oil Co., New Jersey. A special committee of P.I.W.C. consisting of representatives of companies having little or no foreign oil holdings was appointed to study the FOC report. As revealed by *Platt's Oilgram* the Harden report stated:

"As a result of world development the U. S. has an inherent interest in the assurance of peace and economic stability in the postwar world and that as a result oil developments abroad are of critical importance in its foreign policy."

Of the three possible methods of developing oil resources of the world, the report lists government operations, private enterprise and mixed operations, but states that "private enterprise is the surest and soundest choice."

"Private enterprise has developed the requisite managerial skill and operating knowledge, and is already well established. It can operate with a minimum of political complications, as most foreign countries readily admit foreign capital, but few countries, if any, would look with favor upon operations by alien governments.

Government Protection Needed

"The greatest immediate need on the part of private enterprise is the assurance of our government that it will seek to reduce the political risks involved in the use of private capital abroad, and that it will take no steps to discourage the efforts of the nationals of the U. S. to maintain an effective and serviceable oil industry in foreign countries."

The report lists the bare essentials of an immediate foreign policy as follows:

(a) The American petroleum industry should be encouraged to expand its plans for developing the world's oil resources. This encouragement requires assurance that nationals of the U. S. will receive the co-operation of our government in securing a position of vital opportunity with the nationals of other countries and that the government itself will not enter into competition with its own nationals.

(b) Existing handicaps in the oil operations of our nationals abroad should be examined in the light of their incidence upon our national welfare, and efforts should be made to remove such handicaps as originate in the laws and practices of the U. S. American nationals operating abroad must be able to comply with the laws and customs of foreign countries without incurring the risk of violating American laws.

(c) The diplomatic support accorded to our nationals by the government of the U. S. should be as effective as that accorded to nationals of other countries by their respective governments.

(d) The ultimate disposition of oil facilities and supplies developed or paid for abroad by the government of the U. S. in the course of the war should be so designed as to promote the interests of our nationals in the postwar world.

(e) Our foreign oil policy should also include appropriate measures for the return after hostilities of American-owned properties, rights and interests in Axis-held territory; adequate compensation for assets destroyed and damaged, and assurance of an early commercial operation of returned properties.

***This is the second of two articles comprising excerpts from "Peace, Plenty and Petroleum," a book dealing with the background and causes of our present oil situation. The 189-page book, written by Dr. Benjamin T. Brooks, prominent consulting chemist, is being published by the Jacques Cattell Press, Lancaster, Pa. ($2.50). The excerpts are published with permission of the author.**

Co-operate With British

Special co-operation with Great Britain is suggested in the report on the ground that a large part of the known oil reserves involved in international trade are "owned, controlled or under concessions" held by the nationals of the U. S. and Britan. Thus, the report argues, the two governments should take the lead in achieving an agreement on basic principles. It is known that the State Department had such co-operation with the British government under consideration before the Harden report was made.

The Harden report appears to have had two objects; first to register a strong protest against the government being in the oil business either as a partner or as a competitor, and second, to open the discussion as to government and inter-government approval of agreements between oil companies (or other companies) regarding production and marketing of crude and refined petroleum products throughout the world.

The first of these objects seems likely to be achieved. The second objective noted in (b) above, perhaps does not lie within the authority of the State Department. Up to the present time there could be no agreements between American oil interests and those of other nations having to do with control of production, division of the world's markets, agreements as to prices, etc., without running afoul of the U. S. Department of Justice to which the word "cartels" is anathema.

Those who remember the famous Madison, Wis., case, in which oil companies and their officials were convicted and fined for doing what the NRA authorities had approved (an alleged approving letter from Mr. Ickes as petroleum co-ordinator being excluded from the evidence) would certainly pay little attention to such a "policy" set up by the State Department which did not in some way or other have the firm unquestioned blessing of the Department of Justice. The latter has generally refused to review any situation of proposed action involving, for example, the anti-trust statutes, saying in effect, "Go ahead and we will decide later whether to prosecute you or not."

Sufficient Oil Lacking

CONCLUSION: Petroleum and our own need of imported oil in the immediate future, is bringing the dollar back into the American diplomacy. However much the fact may be camouflaged and however distasteful it may be to those who apparently enjoy giving away the U. S., we have been rudely jolted into a reconsideration of our foreign policies regarding world trade and particularly oil produced in foreign fields.

Two facts seem to have brought this about, a realization that we are not finding and evidently cannot continue to find oil in the U. S. sufficient to meet the demands of our peacetime industrial economy, and the almost startling demonstration of World War II that oil is the primary munition of modern war—and that we no longer have enough of it.

Some of the idealism of the Atlantic Charter and the one big happy family idea of *"One World"* apears to be giving way, in the face of ferocity, ruthlessness and destruction of the war, to the conception of a policed world. International co-operation after the war will evidently involve a world rationing of such things as petroleum, with quotas, at least to certain nations.

International agreements regarding oil means Britain and the U. S., and possibly Russia, and this in turn means that private companies must operate within the framework of such government agreements. It means a kind of world wide oil cartel, with the blessing of our own and other governments, although with the foreign policy makers laying down the rules.

It is evident that national interests are still paramount. Even those units of the happy family that were supposed to be most international minded turn out to be intensely nationalistic.

Official U. S. Navy Photograph.

"GHOST" SHIP RETURNS *to Fight Again*

Entirely false were the Jap claims that the USS Minneapolis was sunk in a Pacific sea battle.

The facts are—after the engagement in which the USS Minneapolis accounted for three Jap ships, flames enveloped her bow from waterline to super-structure, other serious damages were caused by torpedoes and shells from enemy warships. The fire was quickly extinguished by the ship's efficient fire equipment. Damages were promptly repaired and she rejoined her fleet—a completely restored "ghost" with renewed fighting punch, ready again to seek and destroy the enemy.

National Foam Fire Fighting Equipment has been adopted and is serving extensively aboard U. S. Navy ships where it has proved its efficiency in extinguishing fires—saving valuable lives and ships.

National Fire Foams are providing fire protection for most oil refineries and many other important industries.

BACK THE ATTACK
BUY WAR BONDS

NATIONAL FOAM SYSTEM, INC.

Specializing in Foam Fire Protection

Packard Building, Philadelphia 2, Pa.

REFINING NEWS and TECHNOLOGY

Crude Runs Boosted 31,000 b/d Over Year Ago on Gulf Coast

Special to NPN

HOUSTON — Crude continued to be charged to stills at a high rate in the first half of April, the Gulf Coast Refiners Assn. reported.

During the period the 11 member companies of the association charged crude to stills at the rate of 111,237 b/d, an increase of 31,000 b/d over the same period of last year. Current throughput is 91.5% of rated capacity as compared to 55% a year ago when the industry in this area was operating under severe restrictions as to charging rate and yields.

Stocks of all grades of gasoline continued to decrease and were reported at 1,359,504 bbls., a decline of 97,000 bbls. from the same previous month. In April, 1942, the gasoline stocks totaled 2,415,525 bbls.

Kerosine stocks at 149,939 bbls. indicate but little change for the month. Demand for kerosine has been brisk and with continued movement to New England in steel drums the stocks of kerosine will continue tight until summer. Diesel gas oil stocks were 36,558 bbls., a decline of 34,000 bbls. in the month.

Base Stocks for Oklahoma's Newest 100-Octane Plant Will Be Hauled by Truck Transport

By David P. Thornton Jr., NPN Staff Writer

TULSA — Oklahoma's newest 100-octane aviation gasoline plant to be operated by Associated Refineries, Inc., is nearing completion near Duncan. It is expected to go on-stream within a few weeks.

Three factors will make it unique among the many 100-octane units constructed to fill war needs: (1) It is a $15,000,000 co-operative plant, leased from Defense Plants Corp. by the eight independent refiners who comprise Associated and which supply required base stocks; (2) base stocks will be hauled to the plant by transport trucks which will return a pay-load of by-products to feed-stock suppliers, and, (3) it is neither a physical part nor attached to any existing refining installations.

The new refinery is located on an 84-acre site five miles south of Duncan. Essentially it will consist of four unit processes—fluid catalyst cracking (Standard Oil Co. of N. J. process), hydrofluoric acid alkylation, butane isomerization and gas concentration. What is said to be one of the largest boiler houses in Oklahoma will furnish process and utility steam; a new 12-in. line laid from Lake Duncan will supply boiler and plant water. Some of the fractionator columns of the plant are 145 ft. high by 15.5 ft. in diameter, weight 174 tons.

Trucks Haul Stocks

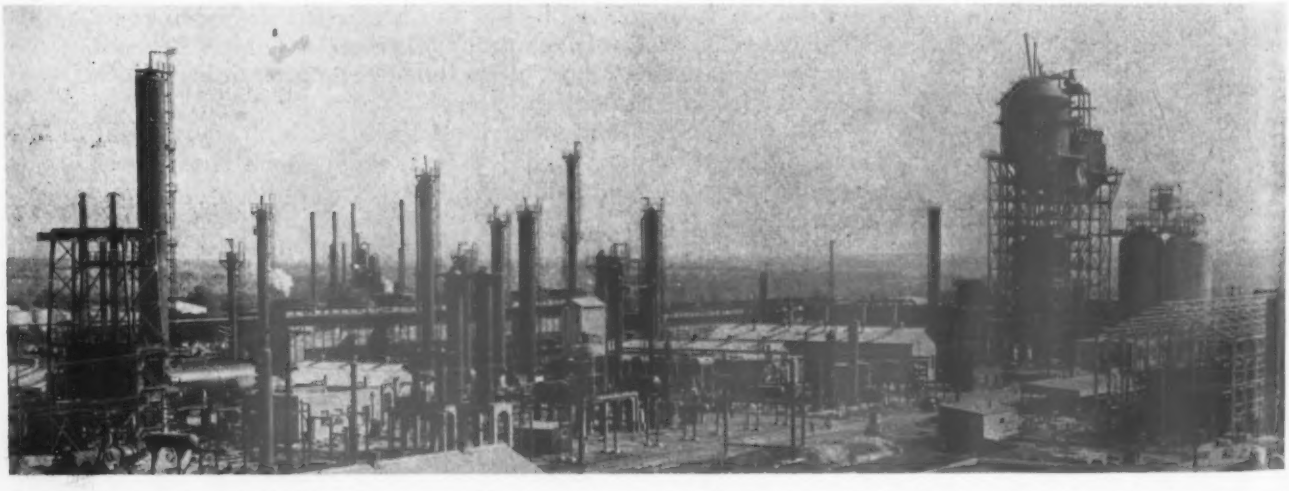
Operating personnel will comprise in excess of 400 skilled men. To house them, Tulsa Defense Houses, Inc., is building 121 homes in Duncan. Two-thirds of the staff is already on the job while, officials say, "desperate" efforts are being made to secure the balance of the staff. Training schools have been in operation for some time to teach women to handle as many jobs as possible. At present, women who have had some high school and college chemistry are employed in the laboratory, with others being trained for boardmen and jobs at the loading docks.

Located as are the participating refineries in an area inadequately served for industrial purposes by rail or pipeline facilities, shortest and most direct transportation can be furnished only by transport truck. A fleet of 30 heavy-duty tractor trucks has been allotted from the 1944 civilian truck pool and just delivered. They are of 149-in. wheelbase, powered by the same type of engine used in half-tracks, and equipped with two-speed rear axles, air brakes, 300-watt generators and 11.00-20 tires. These tractors will haul 4000-4500 gal. tanks mounted on semi-trailers.

Schedules call for 140-150 truck operations per 24-hour day, with round-trip mileage averaging 150 per day; driver's shifts will approximate eight hours. The farthest haul will be from Electra, Tex., a distance of 95 miles.

A factor adding to the economy of truck operations is that equipment will carry full pay-loads both ways. Each of the eight refineries will supply a special gas-oil feed stock for which their plants have been individually adapted to supply in quantities co-ordinated with the other suppliers. In return, they will receive heavy naphthas and other products unsuitable for conversion into aviation gasoline. By-products returned will be proportioned on the same ratio that individual supplier's contribution of base stock bears to total quantity supplied during a given period. To facilitate truck operations, all-weather roads have been constructed and improved in the affected area under a program sponsored by the government.

By the time operations get under way, about 90 drivers will be required, ac-



General perspective of Oklahoma's newest 100-octane plant. At left are some of the fractionator columns in the gas concentration unit, catalytic cracker is at right with catalyst hoppers beside it. Extreme right foreground is the boilerhouse, under construction

The "Natural" Partner of the Automobile

is a Partner in Victory

STA-VOL-ENE
STABILITY ◆ VOLATILITY ◆ ENERGY
IT'S A "NATURAL"

From "six iron barrels" that were the total daily capacity of the first Hanlon plant built in 1908, Natural Gasoline, partner of the automobile, helped to give us the American-Way of Life . . . today Hanlon-Buchanan with thousands of barrels daily capacity is a Partner in Victory, supplying Butanes and Stabilized Natural Gasoline—STA-VOL-ENE the "Natural" known throughout the World.

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Some of the International trailer-type transport trucks used in hauling base stocks from supplying refineries to Associated's 100-octane plant at Duncan, Okla. Fluid-catalyst cracker is visible in background

cording to Dock Supervisor Paul C. Bailey, who is in charge of trucks and accessory automotive equipment and maintenance. Drivers are hired by direct application, of which there have been quite a number, and by referral through U. S. Employment Service.

An extensive system of training drivers and keeping trucks in repair has been worked out by Mr. Bailey. Under him are two head truck drivers, who will be in direct charge of the other drivers and spend much of their time on the road training drivers, checking correct driving habits and emphasizing continual preventive maintenance practices.

Applicants are first given a general check by the personnel department. Then they go to one of the head drivers who examines them thoroughly on their knowledge of general highway driving, state laws, safety and so on. After hiring, a driver is taken on an extended two-day tour of the refinery, during which the importance of the product and need of keeping production at high levels is emphasized. In addition, he receives detailed instruction on construction and operation of truck, trailer and tank carrier. The men are supplied with service manuals and instruction books. Frequent examinations on contents of these publications, conducted by the head drivers, assures that the men absorb the information and are able properly to interpret and use it.

A careful program of preventive maintenance has been mapped out. Each day, when the driver completes his shift, he is required to fill out an inspector's report. If items requiring attention are minor, they are fixed at the dock. More extensive repair and overhaul work will be done in a well-equipped new garage employing a foreman, six mechanics, lubrication expert, a washer and a porter when full operation of the plant begins.

Each 1000 miles the lubrication system, brakes, clutch, steering mechanism, etc., will be inspected, the findings recorded on forms similar to those used by the Army. Every 5000 miles a more extensive inspection is in order, including check of cylinder heads, gaskets, water pumps and universal joints in addition to the above. Drivers must make a daily gauge check of tires and report any unusual wear; a weekly inspection also is conducted by head truck drivers.

The companies associated in the venture and the location of the supplying refineries are: Anderson-Pritchard Refining Corp., Cyril; Bell Oil & Gas Co., Grandfield; Ben Franklin Refining Co., Ardmore; Rock Island Refining Co., Beckett, and Cosco Oil Co., Winnewood, all in Oklahoma; LaSalle Petroleum Co., Burkburnett; Panhandle Refining Co., Wichita Falls, and W. T. Waggoner Estate, Electra, all in Texas.

Officers are M. Lloyd Freese, president; L. B. Simmons, chairman of the board; R. B. Anderson, B. I. Lubell and R. C. Stanford, vice-presidents; H. P. Alspaugh, secretary-treasurer; C. D. Cund, assistant secretary-treasurer, and W. D. Manz, general superintendent.

$2,000,000 Haynesville Pool Community Plant on Way

NPN News Bureau

TULSA — Construction of a $2,000,000 natural gasoline and recycling plant for Haynesville Pettit lime pool, near Haynesville, La., will begin as soon as agreement between royalty owners and 20 companies with holdings in the pool is signed, according to announcement by Ohio Oil Co., owner of largest number of wells in field. Ownership will be in proportion to acreage, companies operating own well with a manager selected to run the plant.

There are 161 producing wells in 13,000-acre field which extends from northern Louisiana into Arkansas. Contract now being signed calls for thorough test of formation below Pettit lime, and oil or gas, if found in commercial quantities, will be produced. No. 1 G. W. Taylor of Ohio and Gulf Refining Co. will be used as test well and work will be started within 90 days after agreement is completed.

Plan calls for lines to be run from each producer to the gasoline plant so that gas now being burned in flares will be saved. After gasoline has been extracted it will be returned to pool for repressuring. A request for priority has been made for all materials needed and has been granted in part. Plant and gathering system is expected to be completed late in fall.

Sinclair's Houston Butadiene Plant Going—Record Set

Special to NPN

HOUSTON, Tex.—First production of butadiene of the grade required for synthetic rubber manufacture was achieved at the Houston plant of Sinclair Rubber, Inc., on April 23, company officials announced.

First raw material hydrocarbon charge to the plant equipment was made on March 30. Under normal operation, the flow of hydrocarbons through the various processing stages is continuous.

Rated capacity of the plant is 50,000 short tons per year of butadiene, sufficient, when combined with the other ingredients making Buna-S type of rubber, to make 60,000 long tons of synthetic rubber per year.

To meet its designed rating, the plant requires a minimum of 8000 barrels of raw charging stock a day. Raw material comes from the refineries of Sinclair Refining Co. and Crown Central Petroleum Corp. at Houston and Pan American Refining Corp. at Texas City. Pipe lines connect the various refineries with the rubber plant.

Butadiene made at Sinclair Rubber will be used by the Goodyear Synthetic Rubber Corp. plant in Houston.

Hawkins Natural Gasoline Plant Starts Operations

NPN News Bureau

TULSA—The new Hawkins (Tex.) natural gasoline plant owned jointly by Natural Gasoline Corp., a subsidiary of Warren Petroleum Corp. and Humble Oil & Refining Co. is being put into operation, it was announced by Warren Petroleum here. It will manufacture various grades of natural gasoline, iso-pentane, iso-butane, normal butane and butane, products required to meet the nation's war needs. Output will be marketed by Warren Petroleum.

Fuels Above 85 Octane Beyond Useful Range Of Present Motors, Pittsburgh S.A.E. Told

By B. H. Weil*
NPN Special Writer

PITTSBURGH—Problems of postwar automobile expectations and wartime transportation and maintenance shared the spotlight at the 15th anniversary meeting of the Pittsburgh Section of the Society of Automotive Engineers here on April 25.

Two papers were presented at the morning session, one on "Rubber Problems, Developments and Prospects" by W. H. Elliott, manager of the field engineering department, The B. F. Goodrich Co., and another on "Aluminum—Its Alloys and Other Light Metals" by Dr. P. V. Faragher of the Aluminum Co. of America.

Mr. Elliott, after reviewing the rubber and synthetic rubber picture, stated that he believed that "Americans will insist on continuing at least standby operation of their synthetic rubber plant after the war," because of the dominating factor of national security. He predicted that postwar tires will eventually be better and cheaper than those made in prewar days.

Transportation and Maintenance

Stating that aluminum production was now proceeding at a rate of over 2,100,000,000 pounds per year, compared with 327,000,000 pounds in 1937, Dr. Faragher pointed out that the capacity for fabricating aluminum has been hugely increased and that methods used are on a scale comparable to those of the steel industry. While he refused to predict that the postwar car will have an aluminum body, Dr. Faragher stated that lower prices for both materials and fabrication should point the way to wide use in postwar automobiles.

The afternoon session was devoted to papers on "Fleet Operation" by S. G. Page, Equitable Auto Co., and "Trucks" by B. B. Bachman, the Autocar Co. Mr. Page discussed wartime extravagancies of operation and the need for plans for fleet reconstruction. Problems confronting truck operators and manufacturers during the war period were dealt with by Mr. Bachman, who also speculated on future developments. A facsimile of the Army Ordnance Department's Distinguished Service Award, recently made to the society, was presented to the Pittsburgh Section.

At the evening session, W. S. James, president of the Society of Automotive Engineers, spoke on "T. & M. in the S.A.E." He was followed by John A. C. Warner, secretary and general manager of the S.A.E., who spoke on "S.A.E. Participation in the War."

Highlight of the entire meeting was the symposium on "Postwar Passenger Car Design". Sponsored by Harold F. Blanchard, editor of *Motor*, the symposium was to have had Delmar G. Roos, Willys-Overland Motors, Inc., as moderator, but in his unavoidable absence his place was taken by R. J. S. Pigott, chief engineer of the Gulf Research & Development Co. who was also one of the four experts who conducted the discussion.

In his role as expert, Mr. Pigott stressed the urgent need for postwar economy and the necessity for saving natural resources as well as money. Stating that the prewar car costs 2 cents per mile to operate and 2.8 cents per mile for fixed charges (an often-forgotten factor), Mr. Pigott advocated less expensive and more economical cars for the postwar era. He believes that this end may be attained by reducing horsepower, cutting top speeds from their unnecessarily high figure, and reducing weights.

A small engine with a cut-in supercharger for power when needed would effect large economies, according to Mr. Pigott, who stated that a reduction in rear axle ratios should also be made. Higher compression ratios and high octane fuels should be used only if economies can be definitely proved, since design problems are increasingly acute as the compression ratio is raised.

Charles A. Chayne, chief engineer of the Buick Motor Division, was the second speaker. He stated that immediate postwar fuels may have octane numbers of 83 for regular-grade and 86 for premium-grade gasoline and that within a few years the octane numbers may be higher than most oil companies are now willing to admit. Stressing that fuels above 85 octane number are beyond the useful range of present engines, he explained the difficult structural problems facing automotive engineers in designing motors to use fuels of greater than 90 octane number. He believes that such motors will require the stiffest available materials, thus ruling out light alloys which, however, may be of help in lightening the weight of bodies if problems of service repairs (now beyond the ability of modern service stations) can be overcome.

Mr. Chayne believes that the cost of high-octane gasolines will come down and that the better fuel consumption attainable will justify their use. While not minimizing problems of roughness and noise, he concluded with the statement that cars to use high octane fuels will be ready when the fuels are at the pump.

Two Ways To Gain Power

Max M. Roensch, who has charge of experimental engineering for the Chrysler Corp., was the third expert to speak. Stating that there are two ways to gain more power or mileage—increasing compression ratios and supercharging, Mr. Roensch first went on to detail advantages of the latter method. While the use of 80-octane instead of 70-octane gasoline in properly designed motors permits a 10% increase in power, supercharging the respective motors causes a 50% increase instead. Mr. Roensch believes that superchargers may first be applied to trucks, where the noise from the blowers or centrifugal pumps is of less significance and where the cost will be overbalanced by operating economies.

Returning to increased compression ratios and the use of high octane fuels, Mr. Roensch described in detail the difficulties involved in obtaining proper valves, piston rings and bearings. Engines for 100 octane fuels are rough and very noisy, Mr. Roensch said, and are out of the question at present for passenger cars. He believes that automatic transmissions and lower axle ratios are keys to greater economies. Designers, according to Mr. Roensch, will have little difficulty in using 80 to 85 octane fuels.

Maurice Olley of the British Army Staff, Detroit, was the final expert to testify. He deplored prewar body designs and weights, stating that the automotive industry has talked functional design and used the opposite. He expressed the hope that postwar competition will create varied and more versatile designs, decrease weights, and end adherence to poorly-conceived but previously self-perpetuating design ideas.

After presentation of the formal papers, the experts then discussed a number of questions in round-table fashion. They agreed that automatic transmissions are definitely coming; that Diesel engines are too noisy, too heavy, and too expensive for near-future passenger cars, although efficient for trucks and busses; that injection systems are too expensive; and that a four-wheel drive is not justified for present use in passenger cars, because of cost, service and tire-wear problems.

*Gulf Research & Development Co.

Delays Penalty in LPG Case

NPN News Bureau

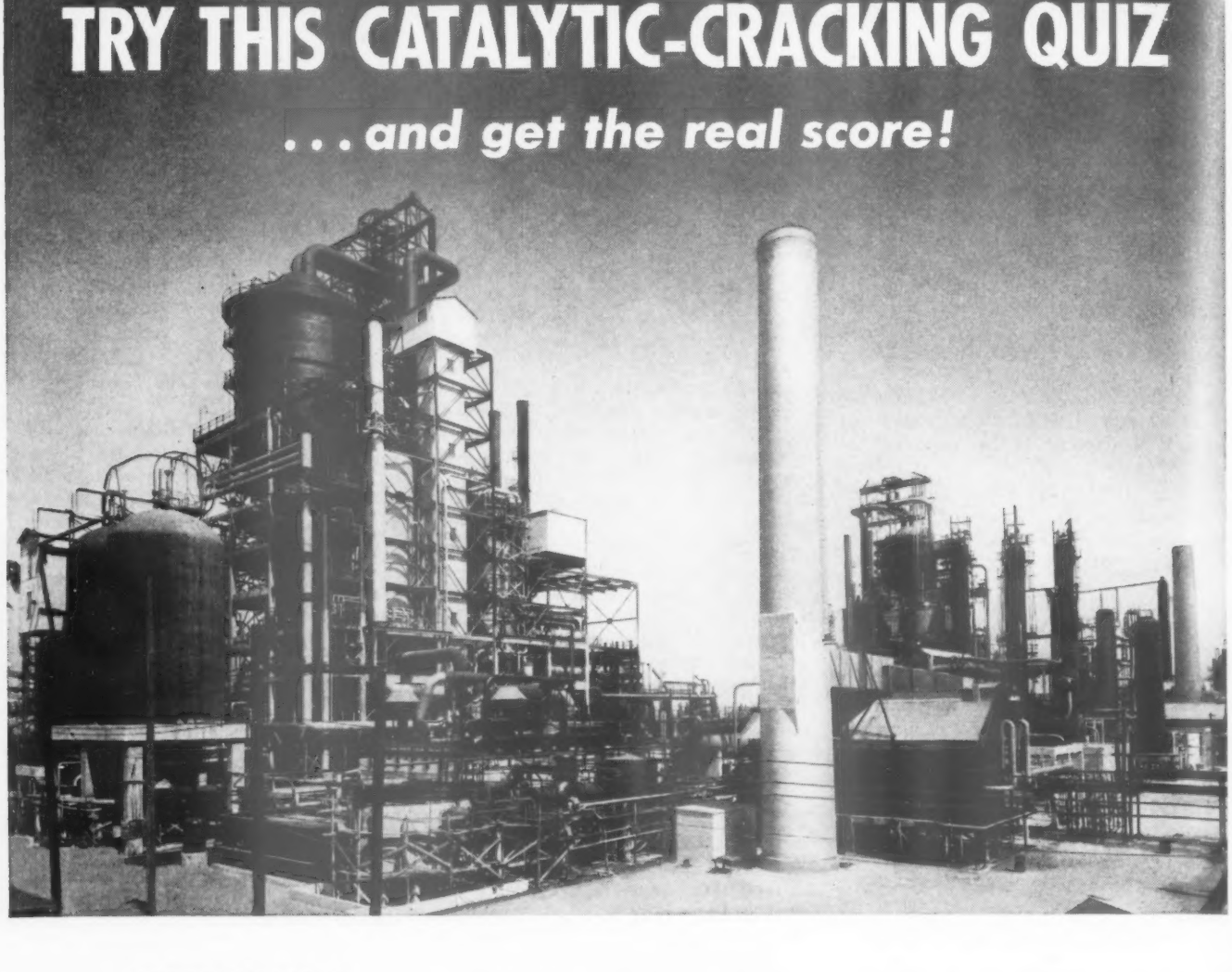
LOS ANGELES — Federal Judge Peirson Hall has informed the government that he will not sentence Lawrence W. Zonker for installing butane equipment on private automobiles until the government informs the court whether it intends to prosecute film stars and other purchasers of the equipment.

Zonker came before the court for sentence on April 28 on his plea of guilty on two counts of a 10-count criminal information lodged against him by the war frauds unit of the Department of Justice.

Judge Hall said he intended to defer sentence of Zonker until the government moves against the persons on whose cars Zonker installed the butane equipment.

TRY THIS CATALYTIC-CRACKING QUIZ

. . . and get the real score!



QUESTION 1: What process now leads in production of the nation's high-octane gasoline requirements?

ANSWER:

Current figures show that when *all* catalytic-cracking fresh feed capacity is considered – including pre-war fixed-bed catalyst processes – the *Fluid* "Cat-Cracking" process now comprises over 50% of the industry's capacity! Further, the ratio of *Fluid* "Cat-Cracking" capacity to that of the nearest competing process is over *two-to-one!*

QUESTION 2: Why are leading refiners sold on this process?

ANSWERS:

1. When built, *Fluid* "Cat-Cracking" plants operate as designed. Production meets specifications. War commitments are realized with efficiency to spare.

2. High efficiency is maintained under a wide variety of operating conditions. For instance, the severity of cracking effected by the ratio of catalyst to charge in the reactor can be varied as much as *twentyfold!* This unmatched flexibility characteristic of the *Fluid* "Cat-Cracking" process permits production today of the all-important high-octane and butadiene components from different types of feeds ... ranging from reduced crude to naphtha. Even high sulphur-bearing feed stocks can be proc-

essed by incorporation of a moderate amount of corrosion-resistant materials in the reactor. *Tomorrow*... this flexibility will permit use of the most economical of feeds to produce premium postwar products.

3. Control of product quality is simplicity itself. Due to the fluid properties of the catalyst... its flow responds to recognized principles. Operating conditions for any run can be quickly established and maintained with little, if any, adjustment of a few simple controls.

4. The flow principle of the catalyst system requires no moving mechanical parts, thus assuring a high service factor. On-stream runs of 4 to 6 months have been reported to date. In addition to this saving in operating time... conventional maintenance costs are reduced to a minimum.

Small additions of catalyst which are easily and regularly injected into the system maintain the catalyst at high efficiency. Manpower costs for operation and maintenance are also minimized.

QUESTION 3: What has M. W. Kellogg contributed to catalytic-cracking?

ANSWER:

On the record... *over two-thirds* of the *Fluid* "Cat-Cracking" capacity built since Pearl Harbor—and now in operation—has been built by The M. W. Kellogg Company. Our laboratory helped develop the *Fluid* technique ... our engineers translated it into commercial reality. Today, our continuous pilot-plant operation provides the accurate data necessary to evaluate feed stocks and to evolve process designs for specific applications.

CONCLUSION:

Based on its war record of production of high-octane and butadiene components... its proven advantages... its postwar future... the *Fluid* "Cat-Cracking" process is the overwhelming choice of leading refiners.

Based on its experience with the *Fluid* "Cat-Cracking" process from laboratory inception and pilot-plant operation through process design and construction...The M.W. Kellogg Company offers an unduplicated "know-how" to refiners planning future installations. Yet this is but one phase of M. W. Kellogg's Complete★ Service to refiners.

Whatever the problem in modernization of existing facilities, our approach to that problem must meet two aims: hasten victory ... provide our client with an "edge" in the forthcoming postwar competition.

The contents of this advertisement have been cleared with the War Department and the Office of Censorship.

THE M. W. KELLOGG COMPANY

★Only Kellogg Service Has Them All

★**LABORATORIES**—fully equipped and staffed—devoted exclusively to chemical engineering and process development.

★**24-HOUR-A-DAY PILOT PLANTS**—17 refining processes operating continuously—providing accurate data for commercial scale application.

★**EXCLUSIVE CHEMICAL ENGINEERING DATA**—Continuously compiled ... embracing both pilot plant runs and the operation of Kellogg-built refineries. Data extends from beginning of modern refining.

★**PROCESS ENGINEERS**—Specialists who have continuously made major contributions to oil refining development, for more than 20 years ... currently exemplified by their work on fluid catalytic-cracking.

★**MECHANICAL ENGINEERS**—Kellogg installations—worth hundreds of millions—are their best reference.

★**METALLURGICAL LABORATORY**—Establishes continuous check of specifications...creates new techniques for the fabrication of refining equipment.

★**PERMANENT CONSTRUCTION CREWS**—Geared to function all over the world on single units or multiphase refineries ... team-experience cuts costs, speeds construction.

★**OPERATING STAFFS**—Specialists at placing new units "on stream"... training of refiner's own operating crews.

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Competition Makes 'Gas' Cheap Commodity, Dallas Meeting Told

Special to NPN

DALLAS—Gasoline is one of the cheapest commodities in the U. S. only because the oil industry is one of the most highly competitive industries in the country, C. A. Young of Dallas, secretary of the American Petroleum Institute's division of production, told convention delegates here last week.

Mr. Young was one of the speakers at the 17th annual convention of the Petroleum Industry Electric Assn. and the Petroleum Electrical Supply Assn. at the Baker hotel.

He pointed out that the petroleum industry is a standout example of how a competitive private enterprise has cooperated within itself to solve practically every problem that required collective effort in furnishing all the oil needed for the war and civilian use, yet at prices no other industry was asked or expected to accept.

"Gasoline is one of the cheapest commodities in America," he told the delegates. "Compare it with the cost of milk, soft drinks, or any other product.

"I have been told that one million of the six million people living in Texas are directly or indirectly connected with the oil business. They either earn their sole living as employes of oil producing companies, oil pipeline companies, refineries and the like, or they obtain some portion of their incomes from royalties or stock in oil companies.

"Yet the public seems to have a decided misunderstanding at times regarding the oil industry. Too many people consider it a monopoly. They fail to consider that gasoline is cheap only because the industry has been, and will continue to be, one of the most highly competitive industries in this country.

"We should inform the public of the facts concerning our industry. In the future a more complete program will be worked out."

U. S. Regimentation Attacked

C. Hamilton Moses of Little Rock, president of the Arkansas Power and Light Co., expressed the belief that Americans must follow their commander-in-chief to the end of the war and like it, whoever he may be. "We must run our business to suit Washington and like it until the war is over," he stated

"When the war is won, we must become vocal. We must put our feet on the ground, rise up and speak out against a continuation of this regimentation imposed upon us under the cloak of war necessity. We can expect Washington to go just as far as it thinks we will stand for. We must have our say about taxes, regimentation, and bureaus."

Mr. Moses said that when the war ends the centralization of power made necessary to prosecute the war must be returned to the states and local government.

J. B. Thomas of Fort Worth, president and general manager of the Texas Electric Service Co., told a joint meeting of the two associations that he believed the vast majority of the people want a middle-road government after the war, "under which a man will have freedom of religion, freedom of speech, freedom to work for whom he pleases and for how much; freedom to profit from his skill, labor and perseverance and to pay for his errors; freedom of opportunity for honest endeavor . . ."

Technical Papers Read

Technical papers were read by Morris Chambers of Shreveport, representing Standard Oil Co. of Louisiana, on "The 100% Efficient Pipeline"; R. T. Fryer, Houston, Westinghouse Electric and Manufacturing Co.; Starr Thayer, Houston, consulting engineer; and L. C. Secrest of Ponca City, Okla.

Brief addresses were made by Mayor Woodall Rogers; E. C. Dwelle, president of R.E.S.A.; P. M. Cordell, president of Petroleum Electric Power Assn.; and F. W. Littell, president of P.I.E.A.

The P.I.E.A. selected Tulsa as the 1945 meeting place and elected the following officers: R. C. Appling, Shreveport, president; M. C. Callahan, Tulsa, vice-president and J. F. Colleran, Tulsa, re-elected secretary-treasurer.

Byrnes Group in Marcus Hook on Coast-to-Coast Tour

Aviation gasoline is the topic of conversation as these three members of the Byrnes special 100-octane committee visited the Sun Oil Co. refinery at Marcus Hook, Pa., at the start of their coast-to-coast inspection of aviation fuel-producing plants. They are, left to right: Rear Adm. Gaylord Church, E. D. Cumming, director of refining, PAW, and Comm. B. W. Gillespie. The visit to Sun's refinery, April 27, was the only one paid an East Coast refinery

Byrnes Group Opens U. S. Tour At Sun's Marcus Hook Plant

Special to NPN

MARCUS HOOK, Pa.—The extent to which the production of 100-octane aviation fuel has been "stepped-up" at Sun Oil Co's refinery was noted here when a group of government officials, known as the "Byrnes Special 100-Octane Committee", toured the refinery on April 27 in celebration of 100-octane's tenth birthday (May 1-7).

At the same time the company announced that it has tripled its output of 100-octane fuel and has substantially increased its production of other types of aviation gasoline.

Construction of a Thermofor catalytic cracking unit, which will cost approximately $4,000,000, is scheduled for completion this summer. Sun at present has a greater catalytic cracking capacity than any other refinery in the world and is one of the chief producers of 100-octane aviation 'gas' for the Armed Forces of the United Nations, the committee was told.

The group left Washington on April 27 and is now on a coast-to-coast inspection tour of 100-octane plants. Sun, the only refinery in the East to be toured, was first on the list.

Included in the group were: E. D. Cumming, director of refining, PAW; George L. Parkhurst, assistant director; George E. Dewey, associate labor counselor, and A. B. Culbertson, chief of aviation section of Refining Division of PAW; George A. Hill, Jr., executive vice president, Defense Supplies Corp.; Michael J. Deutsch, office of war utilities, WPB; Rear Adm. Gaylord Church and Com. B. W. Gillespie U.S.N.; Maj. Morris Levy and M. J. Madigan, special assistant to the under secretary of war, representing the Army, and Brig. Gen. W. B. Pyron and Major B. McClelland.

Strikes Creating Resentment, Jester Tells Rail Unions

Special to NPN

FORT WORTH—Labor is endangering its public goodwill by striking in wartime, Beauford Jester, chairman of the Texas Railroad Commission, believes.

Speaking before the Texas convention of the Railroad Brotherhoods, Mr. Jester said that "you know as well as I do the resentment of our men and women in our armed services over strikes. Their resentment is shared and inflamed by those hostile to union labor."

Jester warned that railway labor must plan and work with railway management in order to meet the challenge that will come from other forms of transportation after the war.

OPA Setting Up Ration Plans For Used Cars, Says Taylor

SAN ANTONIO—The OPA is working up plans calling for the rationing of all used cars, Elliott Taylor, chief of the OPA auto ration branch, told delegates to the National Automotive Dealers' association here last week.

Mr. Taylor pointed out that stocks of gasoline and tires are being replenished, but there will be no additions to the supply of automobiles until after the war.

Huge Mass of Synthetic Tires Soon Go to Drivers; Take Army's Tip — Kid-Glove Handling Needed

NPN News Bureau

WASHINGTON—With all "B" and "C" gasoline coupon holders now eligible for new passenger car tires as a result of greatly increased civilian allocation by the Office of Rubber Director, more and more synthetic rubber tires will be flowing into the hands of service stations and other gasoline dealers.

Service station operators can well take a lesson from the U. S. Army, which already has recognized the difficulties encountered in handling synthetic rubber tires and tubes and has issued a technical bulletin—initiated by the Maintenance Division, Army Service Forces, and published by the Chief of Ordnance—which calls attention to different procedures to be followed in installing and caring for synthetic rubber products, as compared with those made of natural rubber. The bulletin is being issued pending revision of Army technical manuals on tires.

Tips from Army Bulletin

Practically all new tires, tubes and tracks for track-laying vehicles now being delivered for use by troops in the field are manufactured in whole or in part from synthetic rubber, and instructions to soldiers in their proper installation are of first importance, as they also should be for the home-front soldiers—those in service stations and other establishments who must learn to use kid gloves when working with synthetic rubber products.

First off, here are few tips garnered from the new Army technical bulletin:

Special pains should be taken in maintaining correct tire pressures—advice well worth passing on to motorists—because under-inflation is more harmful to synthetic rubber than to natural rubber. Abnormal flexing action from under-inflation creates a relatively higher temperature in the synthetic product, damaging the rubber. Properly inflated, a synthetic tire will flex normally. Over-inflation, because of excessive pressure, likewise makes a tire more susceptible to bruises and otherwise subjects it to greater wear.

Special markings make the new synthetic products easy to identify. Tire casings bear a circular red spot with the letter "S" and a number. Inner tubes have red or blue stripes around their bases. A red spot marks synthetic rubber tracks in the Army.

Installation of synthetic tires requires somewhat different handling than as required for those made of natural rubber, and installation of synthetic tubes demands special precautions. For example, rims must be thoroughly cleaned and all grease, grit, scale and rust removed. Scale and rust seriously damage synthetic rubber tubes.

The casing interior should be inspected for breaks and rough cuts and then cleaned thoroughly. It is imperative that a tube be completely dusted with talc or soapstone before installation since it does not slip into position as readily as a natural rubber tube. It should also be placed evenly inside the casing.

Two-Step Inflation

Since the synthetic tube is not as elastic as one of natural rubber, it is easily weakened and before insertion in the casing it should not be inflated beyond the point where it rounds out. If flaps are used, they also must be dusted with talc or soapstone and must be installed well centered and wrinkle-free.

A two-step inflation process after insertion into the casing is essential. There should be first partial inflation to pull the tube and casing into their approximate positions, followed by complete deflation and then inflation to proper driving pressure.

For a tire mounted on a drop-center rim, the tire beads must be out of the rim—well before inflation to avoid pinching and tearing. Dual tires and all "driven" tires must be closely matched. Since synthetic rubber cuts and chafes more readily than the natural product, avoidance of quick starting and stopping, skidding and overloading and speeding becomes more important.

Now back to the subject of increased civilian allocations of new passenger car tires by ORD.

Effective May 1, eligibility rules for new tires were broadened to include all motorists using their cars for occupational driving—the "B" and "C" book holders.

Previously, the only motorists eligible

Eastward Rail Hauls Average 745,150 b/d

NPN News Bureau

WASHINGTON—Tank car hauls of crude and products to the East Coast averaged 745,150 b/d during the week ended April 22, compared with 749,441 b/d the previous week, PAW reported. A total of 69 companies loaded 25,520 cars as follows:

Abercrombie	180	Derby	8	Roosevelt Oil	13
Aetna	22	Drake	10	Rock Island	8
Allied	39	Elk Refining	26	Royal Petroleum	118
Amsco	203	Freedom Oil	2	Shell	762
Anchor	5	Globe	1,476	Shotmeyer	1
Arkansas Oil	4	Gulf	2,277	Sinclair	989
Ashland Refining	121	Hartol	55	Socony-Vacuum	2,880
Asiatic Petroleum	36	Hess, Inc.	36	Southland	13
Atlantic Refining	1,816	Jenney Mnfg. Co.	87	S. O. California	17
Aurora	10	Libby	4	S. O. Indiana	586
James B. Berry Sons	8	Mid-Continent	21	S. O. Kentucky	36
Cantelou	14	Old Dutch	4	S. O. New Jersey	4,778
Canton	25	Ohio Oil	12	S. O. Ohio	93
Chalmette	14	Pacific	81	Sun	2,407
Cities Service	633	Pan American	1,185	Talco	79
Clymore	8	Pana	4	Taylor Refining	18
Continental	291	Petroleum Heat & Power	6	Texaco	2,058
Consumers	41	Phillips	211	Tide Water	1,147
Cosden	1	Premier	4	Triangle	22
Crown Petroleum	4	Primrose	26	United	41
Daugherty	28	Pure	48	Waggoner	10
Deblois	3	Republic	138	Western Oil	3
Deep Rock	5	Richfield	198	Worth	11

ALL HANDS AT
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INITIAL PLANT OPERATION

War is still America's most serious business of the moment. Industrial efficiency is high—but not high enough. Production is huge—but still short of goals. Both objectives demand the redoubled effort of every loyal individual and concern.

BADGER is knee-and-elbow-deep in the kind of large-scale work for which Badger's long experience is particularly suited. Since Pearl Harbor—and before—Badger services have been heavily engaged in process engineering, design and construction for both Government and private war-production plants in the petroleum, petro-chemical and chemical fields.

The total number of Badger employees engaged on war projects to date would populate a small city. The many construction operations in which Badger has had an important part during the past three years extend through many states and foreign countries. They represent a value approximating the cost of several "Alcan" highways.

Conspicuous are plants for the manufacture of butadiene, alcohol, toluol, tri-nitro-toluene, plus many complete refineries for the production of aviation gasoline.

Badger is thoroughly equipped and manned to assume full responsibility for the complete handling of any size project, from inception to final test-run operation. Around the key personnel of Badger's central organization are technical and laboratory engineers; design engineers and draftsmen; procurement, expediting and accounting experts; seasoned and efficiently supervised construction crews; experienced plant operators.

All these combine to afford the many advantages to be gained from placing everything in the hands of one qualified concern working in close co-operation with your own organization.

Process Engineers and Constructors for the Petroleum, Petro-Chemical and Chemical Industries.

• Licensing Agents for the Houdry Catalytic Cracking Processes; All-purpose Fixed Bed Units, Adiabatic Fixed Bed Units, Thermofor Units.

E. B. Badger & SONS CO.

BOSTON **EST. 1841**

New York • Philadelphia • San Francisco • London

BADGER HAS DESIGNED AND BUILT MORE CATALYTIC CRACKING UNITS THAN ANY OTHER ORGANIZATION IN THE WORLD

for new tires were those entitled to preferred gasoline mileage—drivers included on the list of most essential occupations and generally holding "C" rations. With the new change, any occupational driver with a "B" or "C" gasoline ration may now apply to his local ration board to buy a new tire.

At the same time, light delivery trucks which previously had been able to buy only used tires, were made eligible for new passenger tires as well. The trucks in this category include those delivering ice cream, confections, tobacco products and department and retail store merchandise.

875,000 Go to Boards

Allocations for May of new passenger tires received from ORD for distribution by OPA are to be broken down into a quota of 875,000 tires assigned directly to local boards, and a reserve of 425,000. This reserve will be split into 150,000 to be held by OPA district and regional offices and 275,000 to be held by the national OPA office. The reserves will be distributed during the month to local boards on basis of local needs.

The increased allotments of new tires will make it possible to take care of the minimum needs of occupational drivers, OPA Chief Bowles said in announcing the OPA action, adding: "Everyone realizes that replacement tires must be provided for these drivers, and the Office of Rubber Director has assured us that, barring unforeseen developments, it will be able to make available enough tires from now on to meet the needs of occupational drivers."

He pointed out, however, that tire production is still inadequate to meet any but the most necessary demands. It is therefore as important as ever that motorists continue to recap worn tires, avoid excessive speeds, and thereby get the last mile of wear out of their tires.

Now, briefly, back to the Army and its use of synthetic rubber. U. S. Army requirements of crude synthetic rubber for combat material were reported this week by the War Department, and when reviewed, the huge maintenance task that must be carried on by maintenance soldiers can easily be appreciated.

For example, one 75 m.m. gun carriage requires 404 pounds, a 37 m.m. gun carriage or jeep, 70 pounds; a field ambulance or ¾ ton scout car, 200 pounds; a two-and-one-half ton truck, 270 pounds, and a motorcycle, 14 pounds.

MAINTENANCE MIKE
This is one time G. I. Joe is seein' spots that mean somethin' besides "mornin' after measles"
Those red spots on the tires and the stripes on the tubes mean they're synthetic rubber. That's why he's usin' a lot of talc on the tubes before he puts 'em in the casings -- they've got to be as slippery as you can make 'em on account of synthetic rubber tears easier than natural rubber.
TALC
Watch him inflate the tire part way and then let some of the air out to ease the strain on the tube so's it'll slip in place easier before he blows it up full again.
Synthetic tubes that's handled *careful* like that will give good service -- if the driver's careful too.
S-4

Here's one Army method of urging care in use of synthetics

Railroads Ask Delay in ICC Oil Rate Reduction Order

NPN News Bureau

CHICAGO — Sixteen attorneys representing 13 railroads, composing a committee for all western lines, filed a petition last month with the Interstate Commerce Commission in Washington, asking for postponement of the effective date of ICC's Feb. 24 decision on Docket 28760. The case involves an estimated 10 to 20% reduction in freight rates on low-grade petroleum products from the Mid-Continent area into Minnesota, Wisconsin, North and South Dakota, Nebraska, Iowa and parts of Missouri and Michigan. The order is effective June 7, unless stayed.

Products named in the rate reduction order are distillate fuel oil not suitable for illuminating purposes, residual fuel oil, heating oil, furnace oil, burning oil, Diesel fuel, tractor fuel, gas oil, coal-spraying oil, road oil and asphalt in tank car loads from points in Kansas, Oklahoma, Arkansas, Texas and Louisiana.

The new rates ordered are 80% of rates now in effect under Docket 28106, but oil company traffic men say the new ICC order is not entirely clear, since the per gallon weight of products is involved, and the order is in need of further clarification.

In event ICC maintains its present position and the order becomes effective June 7, oil industry traffic departments anticipate an industry clamor for tank cars for movement of products as the new low rail rates will be in direct competition with pipeline movements from the Mid-Continent and barge shipments from the Gulf Coast and Louisiana. However, the transportation men point out that even though the rate does become effective, all tank cars are new on war assignment by ODT and no additional ones will be available for this new products movement.

ODT Closes Mt. Carmel Office

Special to NPN

MT. CARMEL, Ill.—With the statement that the opening of pipelines to the eastern seaboard has brought about considerable improvement in the orderly flow of tank cars, ODT announced the closing of the western division branch office of ODT's rail transport division, located here.

Production Exceeded Reserves Found in '43, Scouts Told

Special to NPN

DALLAS—Members of the National Oil Scouts and Landmen's Assn. are back at their posts after a record turnout for their 20th annual convention here last week.

E. J. Raish of Austin, executive secretary of the association, said that 170 registered for the session, twice that of any previous meeting.

The scouts and landmen heard Dr. Frederick H. Lahee, chief geologist for the Sun Oil Co., quote figures showing that the 1,423,906,000 bbls. of oil produced in 1943 was more than five times the 271,048,000 bbls. of new reserves discovered during the year.

Dr. Lahee said that new reserves added through extensions and revisions of oil fields in 1943 in the 11-state major U. S. producing areas, added to the reserves discovered in 1943, brought the grand total of new proved reserves up to 1,234,255,000 bbls., or 189,651,000 bbls. short of the amount produced during the year.

The outgoing president, Dell J. Crosby, Humble Oil and Refining Co., Houston, was elevated to the chairmanship of the board of directors. The board consists of the national officers and one representative chosen by each of the 25 district organizations which cover the oil producing areas of the United States.

Other officers elected are Troy Stall, Stanolind Oil Purchasing Co., Midland, Tex., first vice-president; Buddy Robinson, Phillips Petroleum Co., Evansville, Ind., second vice-president; J. L. Smith, Pure Oil Co., Wichita, Kans., secretary-treasurer; and Howard Brooks, Magnolia Petroleum Co., Dallas, editor-in-chief of the yearbook.

Old Oil Wells in Back Fields Revived, Russians Report

NPN News Bureau

WASHINGTON—Hundreds of abandoned oil wells in Soviet Russia's "back fields" have been revived in the last 18 months, according to an article in the Russian trade union newspaper *Trud* reported to the Office of War Information.

A 15-station chain in the Urals, a 5-station chain in Karginsk and a six-station chain in Kazakstan are all projected to start before the end of the year, it was said.

Texas Scraping Bottom of Barrel for Sweet Crude, Jester Warns as State's Allowable Sets Record

Special to NPN

AUSTIN—Texas oil fields in May will again be producing all-time record amounts of crude and condensates for the war effort.

The Texas Railroad Commission, following the statewide oil proration hearing here last week, set the allowable for next month at 2,148,809 b/d, which after deduction for underproduction is expected to yield 1,976,904 b/d. This is an increase of approximately 50,000 bbls. over current output and 16,552 bbls. above the amount requested by PAW.

"We are scraping the bottom of the barrel so far as sweet crude is concerned," Commission Chairman Beauford Jester told the hearing. "If they want any further increase from Texas, they are going to have to take the sour crudes from West Texas." Practically all of the May increase went to fields in the Permian Basin area of West Texas, which will make their crudes available to the new West Texas oil pipelines.

"Miracles never cease—West Texas is coming into its own for some reason," Commissioner Olin Culberson commented.

Changes to Reduce Lawsuits

The commission adopted two new orders. One provides that East Texas wells cannot receive a greater bonus allowable than they are physically capable of producing. The other establishes a basic statewide spacing rule for wells, 330 ft. from lease on property lines and 933 ft. from other wells.

To provide greater flexibility, however, this spacing will not apply to wells which produce from different horizons. The present spacing rule is 330-990 ft. and the PAW regulation 330-900. Jack Baumel, the commission's director of production, said that the changes will reduce lawsuits under the spacing rule and allow drilling on 10 or 20 acre tracts. Exceptions to the rule may still be granted.

In connection with the East Texas order, Mr. Baumel reported that 122 wells were found in a January survey to be earning a greater bonus allowable than they can produce. These wells with allowables totaling 572 b/d earned 918 bbls. bonus for reinjecting salt water, of which they produced a total of 45,879 b/d. By eliminating any bonus allowable above their ability to produce, an additional 16,089 bbls. of water daily would be kept under ground, Mr. Baumel testified, by removing the incentive to produce water just to get a transferrable bonus allowable. The order also provides that bonus allowables shall not be granted until the second month after the reinjection occurs, eliminating retroactive allowables.

H. P. Nichols of the East Texas Oil and Gas Assn. said that he understood some present oil production from the field is going into storage, which his association opposes. He said that in spite of a five pound increase in the field's bottomhole pressure in March, the field should be cut down below the present 22 production days. (The commission's order sent the field back to 23 production days, after cutting it to 22 for one month.)

Booklet Toots Horn for Kansas As Nation's Fifth Oil State

TOPEKA—A comprehensive, multicolored brochure, "Let's Look Into Kansas," describing the state's vast natural resources and industrial opportunities, has been issued by the Kansas Industrial Development Commission.

"Kansas produced 96,879,000 bbls. of oil in 1942," the brochure said, placing the state fifth in the nation in petroleum production. "As of Jan. 1, 1943, a total of 20,551 wells were producing in the state and the estimated reserves were 896,819,000 bbls.

"Kansas exceeded 43 states in the production of petroleum for the ten-year period, 1932-41, with an average annual production of 57,739,400 bbls. Nineteen refineries are operated in the state.

"Petroleum and natural gas in commercial quantities are produced in 62 of the 105 counties," the brochure said.

Natural 'Gas' Output Spurts In Mid-Continent, Gulf

NPN News Bureau

TULSA—Production of natural gasoline in Mid-continent and Gulf Coast totaled 131,782,726 gal., increase of 12,344,845 gal. over February, on grade 26-70 basis, according to March, 1944, report of Natural Gasoline Assn. of America.

Largest single contribution to the March, 1944, total was Texas, with 74,453,868 gal. of grade 26-70 equivalent, followed by Oklahoma with 26,439,660 gal. Other figures were Louisiana, 9,762,185; New Mexico 6,574,625; Illinois, 6,121,666; Kansas, 5,088,885, and Arkansas, 3,341,837.

Mountain View Postings Revised

Special to NPN

SAN FRANCISCO—California Standard recently announced a revision in postings for crude purchased in the Mountain View Field, Cal., amounting to increases of from 1c to 18c, effective 7 a.m. April 14.

New schedule posts 98c for 19-19.9 to 22-22.9 gravity; 23-23.9 grav. at 99c with 4c differential per degree to 28-28.9 at $1.19; 29-29.9 posting is $1.24 and 30-30.9 pays top of $1.28. Old posting began with 98c for 19-19.9 to 26-26.9 grav., 27-27.9 at $1.01 with 3c differential per degree to 30-30.9 at $1.10, 31-31.9 at $1.14, and top was 32-32.9 at $1.17.

Officers who will handle the affairs of the Michigan Petroleum Assn. for the coming year photographed at the association's annual spring meeting in Detroit, April 25-26, left to right: Joseph D. Hadley, Detroit, executive secretary; James E. Truesdell, Flint, and Leigh Morden, Lansing, re-elected treasurer and secretary, respectively; Galen Wilson, Saginaw, new vice-president; and John W. Jankowiak, Pinconning, re-elected president

PDO 1 Condemned as 'Unnecessary and Unfair' by Michigan Assn.

No Postwar Control of Oil Prices Seen After War—Judd; McCaleb Predicts 'Beautiful Future' For Petroleum

By Earl Lamm
NPN Staff Writer

DETROIT — About 200 oil men attended the 10th annual spring convention of the Michigan Petroleum Assn. convention at the Detroit-Leland hotel here April 25-26, at which a resolution was adopted roundly condemning PDO 1 as unnecessary and unfair and resolving to bring it to the attention of U. S. Attorney General Francis Biddle on the grounds that it will, in the opinion of the association, force unwilling and illegal discrimination on the part of each and every petroleum marketer.

Apparently the oil men had their minds made up in advance as to the stand they would take on the proposed new PAW distribution order, for although hotel lobby conversation centered upon it, the order was not mentioned at the assembly on the first day when Walter Hochuli, PAW director of distribution and marketing, addressed the convention.

Other speakers on the program were O. D. Judd, OPA petroleum price executive; Charles M. Ziegler, state highway commissioner; Herman Dignan, secretary of state for Michigan; S. N. McCaleb of the Detroit office of Socony-Vacuum, and Harry Nankervis, PAW Dist. 2 assistant director of distribution and marketing.

President John W. Jankowiak and all other officers were re-elected, except Vice President Paul R. Kempf, whose service on Dist. 2 and other industry committees takes up his time. He was succeeded by Galen Wilson. Five new directors were elected, succeeding those whose terms expired. They are: Frank Fehlesenfeld, Grand Rapids; Russell Boyer, Harrison; Arthur Crawford, West Branch; Gerry E. Macklin, Sheboygan, and William Landevere, Newberry. All other directors were continued in office.

Posed between sessions at the Detroit convention of the Michigan Petroleum Assn., April 25-26, are, left to right (seated): W. E. Beier, Maine City; A. D. Dubuisson, South Haven; Gerry E. Macklim, Sheboygan; J. F. Wilson, Port Huron. (Standing) Otto J. Eisengruber, Sebewaing; A. J. Buese, Alma, and C. H. Kaiser, Port Huron

Judd Hails Jobbers

In his talk, which he read from script in accordance with the government agency prescribed formula, Mr. Judd declared that jobbers represent an important segment of the oil industry—"a segment which we believe serves a definite and necessary function in the distribution of petroleum products."

"You have heard and read that your days are numbered," he continued, "that in the postwar period your function will be absorbed by other existing levels of distribution; that competition between large marketing organizations will eliminate your place in the scheme of things."

But, he said, every official of the larger companies calling on OPA in Washington had held a different view —that jobbers perform a necessary function. They believe that competition after the war, however, will influence jobbers

Houdry let cat-cracking out of the bag!

First process to produce motor fuel in commercial quantities by catalytic cracking . . . 1936.

First process to produce aviation fuel by catalytic cracking . . . 1937.

First process to produce cracked gasoline satisfying U. S. Army Specifications for aviation fuel . . . 1938.

★

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WILMINGTON, DELAWARE

Houdry Catalytic Processes and the T.C.C. Process are available through the following licensing agents to all American refiners, subject to approval by the United States Government.

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Boston, Massachusetts

HOUDRY CATALYTIC PROCESSES
... FOR VICTORY IN WAR
... FOR PROGRESS IN PEACE

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to make refinements in their methods of doing business, he said.

As for the present, he asserted that OPA took no price actions involving jobbers even indirectly without giving serious consideration to the welfare of the jobber group. He cited these price adjustments as points of fairness to petroleum distributors:

OPA helped secure cancellation of 6% freight rate increase in 1942, since some jobbers bought products at delivered prices; prevent suppliers from switching from delivered to F. O. B. origin prices without OPA approval; increased heating oil margins .3c per gal.; established tank wagon prices at those of maximum reference seller and adjusted subnormal tank wagon prices in 11 Mid-Western states or increased them .7c per gal.

Regarding further increases in jobber margins, Mr. Judd said OPA is restricted by the Price Control Act and executive order. He expressed regret at failure to receive sufficient replies to the jobber margin questionnaire last year, and hoped that the low point has been reached in business volume and that any change would tend to improve the jobbers' position.

Discusses Price Adjustment

"You are of course free to petition for a price adjustment at any time," he continued. "I cannot promise that your petition will be granted, but I can say that it will be studied carefully and given every consideration. I believe you know that we are free to increase prices only in cases where it is shown that hardship to a majority of an industry exists. General hardship is interpreted to mean that a majority of an industry is not earning profits of a normal peacetime period. Where such data are available, the years 1938-39 are considered the base, but where not available, the year 1941 is used."

Mr. Judd next informed the association that men from the industry were now in important positions with OPA, and that when hostilities cease they expect to return to the industry, as the majority opinion of those men is that there will be no need for postwar control of petroleum prices.

"Inflation is a sort of nebulous term," he said in speaking of the present, but quoted some historical figures to show its effect. He said China is the only Allied nation experiencing uncontrolled inflation and that coolie sandals costing 10c a pair normally, cost $14.30 in September, 1943; 50c work shirts have jumped to $72, and a normal 25c meal now costs $36.

Attention was then directed toward another phase of price control as he asked the oil men to appraise their own position in the present shortage of products. He then asked if they would still be in business if there were no price controls or if stronger marketing organizations would not have taken them over. Conceding that they were still in business, he concluded that their purchasing power would be considerably less than now.

In his talk, Mr. Hochuli reviewed the outstanding accomplishments of the petroleum industry in supplying war needs, and touched upon overcoming the black market in gasoline, which he said was an OPA function, but added: "The oil industry, the marketer, if you please, should give his full co-operation and support to the elimination of this activity, which might easily lead to a postwar situation that may be very serious to the industry."

Competition for Better

Prophesying what lies ahead, he declared: "It is safe to say that as long as the war lasts, and at least for some little time thereafter, we will be faced with an insufficient supply of petroleum to meet all needs . . . ." when it's over . . . . "you marketers will have many adjustments to make. You will have profited, I'm sure, by the many things you have learned . . . . from your competitors . . . . and they in turn will benefit from their associations with you."

"This does not mean that competition will be less keen," he emphasized, "for

Orville D. Judd, OPA petroleum price executive, addressing the Michigan Petroleum Assn. at Detroit

I prophesy that the opposite will be true. I look for keener and more intelligent competition, competition for better and more profitable accounts with less concern over volume for volume's sake."

Mr. McCaleb traced the bounding growth of automobiles from the first five cars registered in 1895 to a total manufacture of 86,000,000 cars by Feb. 10, 1942, when the automobile industry came to a dead stop on government order. Plotting the curve upon a large chart, he showed the decline in car registrations since that date and the probable future, including a two-year postwar climb back. Commenting on the gasoline they will use, he declared: "Market looks good—petroleum has a beautiful future!"

Then, in convention spirit, he played stud poker with his audience, using cards about 2½ by 3 ft. in size. He dealt the first card face down on an easel by the speaker's platform.

"That card represents something," he emphasized. "But you can't peek! It's my hole card."

The king of hearts, face up, came next. "That card represents your postwar source of supply," he explained. "Write your own ticket! Is it strong—weak—or what?"

Queen of hearts, he designated as product brand; the jack and 10 spot as advertising and outlets. "Are they strong—weak—or what?" he repeated. "Are you satisfied?"

Returning to the hole card, he turned it over. It was blank. "That," he declared, "represents you. You were expecting to see the ace of hearts, but the card is blank, so you are a question mark. Are you strong—weak—or what? To summarize, petroleum has a beautiful future down the road—but you've got

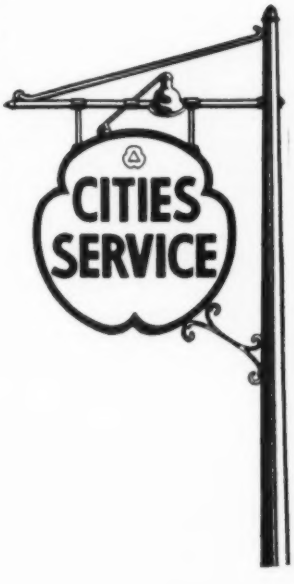
Listening to O. D. Judd tell of OPA achievements, left to right, are L. R. Kamperman and Reid Brazell, Leonard Refineries, and Galen Wilson, Franklin Oil Co., Saginaw

Why I sell Cities Service Products

"BECAUSE Cities Service helps insure my investment in the future . . .

"I'm an independent businessman, and I want to remain independent. The fruits of my work are invested in my business. Cities Service appreciates this. It encourages me to give the type of service that is worthy of the high quality of the Cities Service Products that I sell—and it assists me in every way possible to build my business.

"I can look to the future with full assurance that my investment is secure—backed by the knowledge that everything Cities Service develops is and always will be at my disposal."



Popular Cities Service Products and Services for the Fleet Operator:

KOOLMOTOR MOTOR OIL
TROJAN GREASES
CISCO SOLVENT
CISCO PEP
RIDE PROVER SERVICE
POWER PROVER SERVICE

Snapped at the banquet at the Michigan Petroleum Assn.'s annual session in Detroit April 25-26. Left to right: Ralph Pitcher, North Branch; Clarence Church, Auburn Heights; Claire Ross, Bad Axe; George Eppler, Auburn Heights; Alf Krueger, Bad Axe; M. D. King, Findlay, O., and A. A. Aronson

to have what it takes when the boys come home!"

Mr. Nankervis told of the considerable effort PAW Dist. 2 office has put in on manpower surveys, which so far have been bogged down at WMC headquarters where designation of "locally needed" has been held up. This delay, he thought, would very shortly be overcome.

Secretary of State Herman Dignan, who spoke in Governor Harry F. Kelly's place on the program, presented the governor's regrets because of his inability to be present. An energetic speaker, he recognized the importance of petroleum, the automobile and good roads. However, the subject of highways was covered by State Highway Commissioner Charles M. Ziegler, who reminded the oil men that the last legislature set aside $5,000,000 for postwar highway repair. State Planning Commission, he said, has 22 surveyors out at this time, getting field information on about 300 road construction projects for postwar employment.

The convention closed with entertainment in the hotel's Jade Room in conjunction with the Detroit Industrial Safety Council's petroleum division. Guest speaker was Capt. A. A. Dickerson, with Detroit Oil Men's Club as sponsor.

No worry about PDO 1 here. Left to right (seated) are R. P. Fleckenstein, Flint; C. J. Crimpton, Battle Creek; C. H. Kiskadden and Glenn Pratt, Detroit; (Standing) Pat Kelly, Bartlesville, Okla.; D. G. Taylor, Flint; A. Van Elst, Marshall

A.P.I. Committees Appointed For Houston Spring Meeting

Special to NPN

HOUSTON—American Petroleum Institute this week announced the names of committeemen planning the spring meeting of Southwestern District, A.P.I. Division of Production, to be held June 13-14 at the Rice Hotel here.

L. E. Barrows, The Texas Co., heads the general committee on arrangements. Members of this committee are R. F. Cann, Oil Well Supply Co.; N. B. Cummings, The National Supply Co , W. G. Fitzpatrick, Continental Supply Co.; A. J. Galloway, Shell Co., Inc.; George A. Hill, Jr., Houston Oil Co. of Texas; George O'Leary, Houston Oilfield Material Co.; J. H. Russell, Gulf Oil Corp.; E. H. Salrin, Tide Water Associated Oil Co.; George Sawtelle, Kirby Oil Co.; George Strake, Gulf Building; John R. Suman, Humble Oil & Refining Co.; and Harold H. Wilson, Frick-Reid Supply Corp., all of Houston.

The program committee is headed by A. W. Baucum, Houston, The Texas Co. Members are T. H. Andrews, Houston, Stanolind Oil & Gas Co.; J. M. Cooper, Houston, Gulf Oil Corp.; Bob Kyner, Kilgore, East Texas Engineering Assn.; V. J. Martzell, Shreveport, La., United Gas Pipe Line Co.; and W. E. Winn, Dallas, Sun Oil Co.

E. M. Fontaine, Houston National Tank Co.; and R. E. Bridges, Houston, Humble Oil & Refining Co., head the hotel arrangements and registration committees, respectively.

Kentucky Petroleum Committee Considers Future Program

Special to NPN

LEXINGTON, Ky.—The Kentucky Petroleum Industries Committee met here recently, prior to K.P.M.A. annual meeting. The program included a review of legislative session results, consideration of future program and a report on progress to date on the committee's municipal license reduction campaign. (Considerable time was devoted to the load limit revision campaign which was defeated in the last General Assembly. Strategy to be used from now to the 1946 session of the state legislature was discussed and will be viewed further at the next meeting on May 12. Members of the executive committee are:

P. E. Cochran, C. W. Healy, C. E. Bauer, John Downing, W. S. Glore, Jr., S. C. Harlin, J. P. Hughes, J. B. Hutchinson, R. D. McClaran, J. W. Newbolt, Dan Raibourn, A. J. Sehlinger, H. V. Stephany, O. T. Tarrier, C. H. VosKoetter, P. T. Williams.

Coming Meetings

MAY

Southeastern Oil Jobbers Conference, Ansley Hotel, Atlanta, Ga., Tues., May 9.

Arkansas Independent Oil Marketers Assn., spring convention, Hotel Albert Pike, Little Rock, Ark., Thurs., May 11.

Independent Oil Men's Assn., annual convention and war conference, Hotel Statler, Boston, Mass., Thurs., May 11.

Society of Automotive Engineers, national Diesel fuels and lubricants meeting, Hotel Knickerbocker, Chicago, Ill., May 17-18.

American Petroleum Institute, Mid-Continent Dist., annual spring meeting, Mayo Hotel, Tulsa, Okla., Thurs.-Fri., May 25-26.

JUNE

American Petroleum Institute, Southwestern District, spring meeting, Rice Hotel, Houston, Tex., Tues.-Wed., June 13-14.

It's simple arithmetic

If you have 10 onions — or potatoes, or cabbages — and Uncle Sam takes half, that's five onions for the boys in uniform. But if there are 12 onions to divide, *the boys get six.*

That makes it as clear as 2-and-2-are-4 why everybody with a place for a Victory garden should be starting a Victory garden. Plain arithmetic says your garden actually will help feed our fighting men.

We all want our service men to have plenty of the best. To that end — as with meat and gasoline — the rest of us often go short. Only seldom — as with nylon — do our soldiers, sailors, and marines get *all.*

Instead, Uncle Sam usually divides up the supply—*this* much for the fighters, *that* much for the home folks. The bigger the supply, the more there is for *both* the home front and the fighting front.

Because this is clearly true with food, Standard of California would like, in support of Uncle Sam's current Victory garden campaign, to remind you why Victory gardens are so important to the war effort.

Perhaps you don't realize it, but last year Victory gardeners almost *doubled* the vegetable supply Uncle Sam had to divide up. In 20 million gardens, they grew 40 per cent of the total.

This year the need is for 22 million gardens. The assignment to Victory gardeners is to boost their share of the total supply of vegetable foodstuffs by 10 per cent. Eleven gardens are needed where 10 grew before.

It calls for recruits and replacements—all that can be had. So reach for that spade. Pick up your hoe, madam. The more you raise, the more there'll be — *for all.*

STANDARD OF CALIFORNIA

E flag, with 2 stars, awarded to our Richmond Refinery

Even such a serious subject as car-saving service can be promoted by the deft touch of humor, Standard of Indiana believes. Above cartoons by Lichty are being used in the company's new advertising campaign

Stress Car's Lack of Care, Not Age, in Spring Change-Over

Make Most of Extra Profit Possibilities Now, Dealers Told; Companies Devise New Ideas in Stimulating Sales

By Herb Taylor
NPN Staff Writer

The traditional oil company ritual of a spring change-over campaign is being observed more aggressively this year than ever before. Seemingly, with the last car off the assembly line a veteran of 30 months, and with a save-it-or-walk conscious public, putting over the campaign would be an advertising man's holiday.

But the opposite is true. With labor problems as they are; with many dealers having more business than they can handle anyhow, management has the added problem of selling its own personnel and dealers on the necessity for an aggressive, or any, sales promotion program.

Management is not viewing this as a routine spring change-over activity. Quotas are not being set up on a gallonage or pound basis. There is no place in the plan for temporary, quick profits. Permanent, dependable, after war business is the theme. Oil company management is looking upon this year's campaign as the first shot in the coming postwar marketing battle. There is not a top flight marketing executive in the industry who doesn't predict that the postwar marketing battle will be a commercial war that will make past business-getting scraps as tame as kids playing store.

Cars Need Better Care

The general theme of all of this year's spring change-over promotion is that the lack of care, not age, makes cars grow old. The men in the stations are reminded that the spring of 1944 with cars now in the third year of operation under war time restrictions, they need better care than ever. Dealers who may be concerned about the various estimates of cars going off the road and the possibility of a collapse in business are given a picture of the millions of wartime cars still running and the potential trade for the alert dealer in preserving these cars. The advertising to the public tells the story in various ways that cars and trucks must last for the duration, and that victory even depends upon them. This story is approached from many different angles.

For instance, Standard of Indiana is approaching the serious car saving service from the humorous side. That company tells its dealers that it is always good psychology to get customers and prospects into a good humor before trying to sell them. As the first step the company has worked out a "Mom and Pop" series of newspaper advertisements. These cartoon type ads, designed by Cartoonist Lichty to get the country's average "Mom and Pop" car driver interested, will run in middle-western newspapers in April, May and June. The 3rd-War-Year service guide will be featured or mentioned in every ad. (See illustration).

This feature is designed to stretch car life by encouraging customers to get service on regular schedule. The entire campaign is backed up with many novel points of sale promotion items, banners, posters, direct mail, and a radio program.

The Texas Co. through its company magazines, dealer publications and sales meetings is doing an intensive selling job to its dealers. They are being told that now is the time to make the most of the extra-profit possibilities that exist during this season of the year, not only in the field of automotive services, but in the many merchandising lines that customers are buying at service stations these days. Here briefly are some of the things that dealers are told to do:

Be sure that the station presents an attractive, inviting appearance.

Feature attractive displays of seasonable merchandise.

Be sure that lubrication and other

How to Conserve Anti-Freeze

WPB recommends the following procedure for the conservation of permanent-type anti-freeze solutions, beginning with the removal of the solution from the cooling system at the end of cold weather:

1. Fresh inhibitor of the proper type should be added to the contents of the radiator one week before draining time. This allows ample time for a thorough mixture of the two solutions. (Consult your anti-freeze supplier concerning the type of inhibitor to use.)

2. When drained, the solution should be filtered through a closely woven cloth in order to remove all rust particles.

3. A glass container gives best protection for storage. A clean tin can is also satisfactory. Containers should be tightly capped.

4. Sediment formed during the storage period should be carefully removed before the anti-freeze solution is reused.

5. Also, before reuse, the solution should be tested to determine its freezing strength. The addition of a small quantity of anti-freeze will usually be necessary to bring the solution up to its proper strength.

If you are interested in TIRES

Send us this letter

Pennsylvania Rubber Company,
Jeannette, Penna.

Gentlemen:

We understand that your company has a detailed knowledge of oil industry problems ... and that a special staff is prepared to help oil companies select proper lines of merchandise, and to give complete advice on planning, advertising and selling.

Industry figures show that you are large enough to assure prompt, substantial shipments to all areas, yet are not too big to give executive attention to our particular needs.

We've heard that Pennsylvania Tires are the finest tires available for the money ... and that the line offers tires for every wartime need — whether for retail or wholesale distribution, or for our own business vehicles.

Finally, we've been reading about a new Pennsylvania Silent Vacuum Cup tire that will dominate the quality market after Victory.

Because we are thinking seriously about tires now and for the peacetime future, we'd like to talk with you.

SIGNED _____

ADDRESS _____

_____

521

PENNSYLVANIA TIRES

MANUFACTURED BY THE ORIGINATORS OF THE *Silent Vacuum Cup Tire*

service and repair equipment and tools are in good working order.

Set up an appointment system for handling car services.

Feature as many services coming under the following general headings as possible: lubrication, motor, cooling system, ignition and battery, fuel system, lights, wheels, steering mechanism, brakes, universal joint bearings, shock absorbers, springs, clutch, tires, accessories, appearance.

Feature Variety Merchandise

Feature as wide a variety of merchandise for home and car, lawn and garden, work and recreation, as you can profitably.

Add new lines to replace revenue lost on restricted items.

In addition to a larger advertising program this year, Texaco's Fred Allen is plugging the campaign on his broadcasts.

Many of the companies feature spring change-over service in packages at a flat price. Sun Oil Company dealers are featuring the "1944 Sunoco Spring Changeover Special". This special consists of changing motor oil and gear lubricants to the recommended summer-type; checking of the battery, radiator and tires; the chassis and running gear receive an inspection; spark plugs are cleaned and adjusted; the fan belt and hose connections are inspected and lights and windshield wipers are checked. Sun's spring campaign is being backed with every form of advertising.

In all the spring promotion, the Big Four standbys remain the same. These are

1. Crankcase service
2. Gear oil service
3. Chassis lubrication
4. Radiator service

Instruction on Anti-Freeze

Many of the companies are instructing their dealers in the proper procedure in conservation of anti-freezes. They point out that while restrictions on the sale of "permanent type" anti-freeze solutions to civilian motorists have been eased somewhat by WPB, production is not expected to be sufficient this year to supply the full requirements of civilian passenger cars next winter. (See box elsewhere in this article on WPB's recommended procedure for the conservation of permanent type anti-freeze solution).

Batteries and spark plugs are coming in for considerable promotion this change-over period. One of the companies in helping dealers plan their spring merchandising program points out that $7 per car will be spent during 1944 for new batteries. One of every three cars and trucks, they state, will need a new set of spark plugs this year. The retail revenue in this line is estimated at $2.12 per car.

Battery sales possibilities are also better now that dealers can stock batteries free of the previous restriction which limited a dealer to a 90-day supply. Dealers are told to promote to their customers the fact that to get the maximum life and service out of a battery, it needs to be checked regularly and recharged whenever necessary.

This spring finds increased stocks of passenger car tires becoming available. The military and civilian demands for tires continue to exceed the supply, but more tires for civilians will be available when synthetic rubber production reaches full capacity. This is expected the second half of this year.

Much detail has been omitted in the selling of tires. OPA has lifted its restrictions on inventories of tires and tubes held by dealers. They are now permitted to acquire as many tires and tubes as they wish as long as they surrender the replenishment portion (part B) of the car owner's tire ration certificate for each tire they buy. OPA has also exempted the large majority of tire dealers from the provision in tire rationing regulations requiring filing of quarterly reports of their inventories of tires and tubes.

Recapping Service Featured

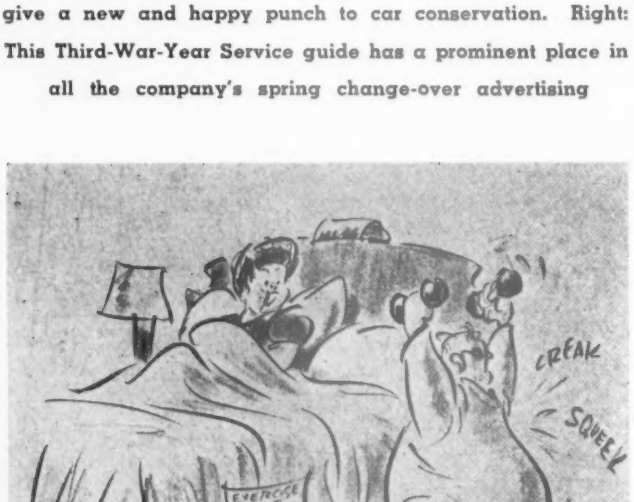
Tire recapping service will also be a profitable featured part of the '44 change-over program. Recapping of passenger cars requires no kind of rationing certificate. Sufficient camelback to recap 20,000,000 passenger car tires this year is being produced by the rubber manufacturers.

Among services some of the major companies are urging their dealers to take on to replace merchandise "gone to war" is car washing service.

Esso reports a survey conducted by

• • •

Mom and Pop and the Car cartoons, created by Lichty, famous cartoonist and creator of "Grin and Bear It" cartoons, give a new and happy punch to car conservation. Right: This Third-War-Year Service guide has a prominent place in all the company's spring change-over advertising



"That reminds me George - we ought to have the car lubricated!"

CUT THIS OUT AND KEEP IT HANDY

"Here's the easy way to make your car run better, last longer. Just follow this guide. I'll do the rest."

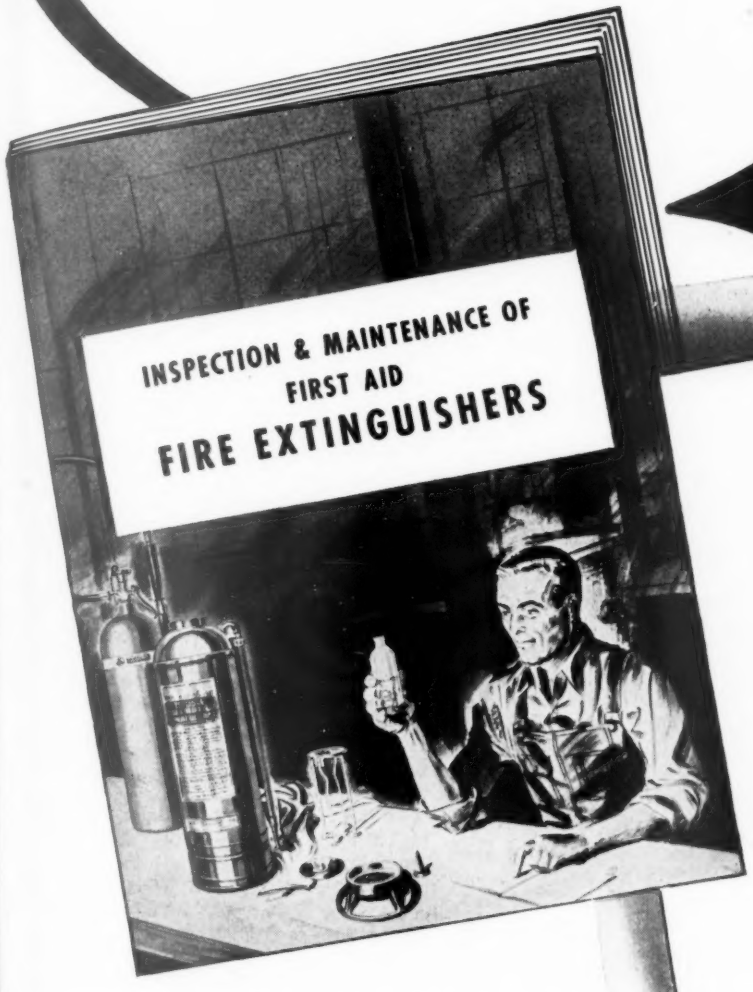
3rd-War-Year Service Guide

ITEM	HOW OFTEN
Crankcase drain (oil change)	60 days—or 1000 miles—whichever comes first
Chassis lubrication	60 days—or 1000 miles—whichever comes first
Oil filter replacement	Spring and fall
Air cleaner cleaning	Spring and fall (or every 3000 miles)
Battery check	2 Weeks
Battery capacity test	3 Months
Tire pressure	Weekly
Transmission and differential lubrication	Spring and fall
Radiator clean-up	Spring and fall

The following important items need occasional attention. (Ask your Standard Oil Dealer's advice.) Front wheel bearings, universal joint, spark plugs, brake cylinders, shock absorbers, carburetor, distributor points.

Make an early appointment with your Standard Oil Dealer for better car care. Weekdays, if you can, please.

Let this FREE BOOK help you keep your fire-fighters ready for action!



PARTIAL LIST OF CHAPTERS

- WHO'S IN CHARGE?
- KEEPING RECORDS
- WHAT KIND OF EXTINGUISHERS?
- MARKING LOCATIONS
- MARKING THE EXTINGUISHERS
- INSPECTION OF EXTINGUISHERS
- VAPORIZING LIQUID EXTINGUISHERS
- CARBON DIOXIDE EXTINGUISHERS
- SODA-ACID EXTINGUISHERS
- FOAM EXTINGUISHERS

NEGLECT of your extinguishers may leave them damaged, clogged, under-charged — *unprepared* at the critical moment when you need them. Only careful examinations at fixed intervals can insure the full effectiveness of your equipment at all times.

To make it easy for you to organize your own maintenance system, Walter Kidde & Company has issued this booklet. The panel at the right gives some idea of its scope. Take the first step toward better fire protection now — write for your free copy of this booklet!

WALTER KIDDE & COMPANY, INC., 536 MAIN STREET, BELLEVILLE, N. J.

the Opinion Research Corp. in Scranton, Pa. and Peoria, Ill., which revealed that 64% of drivers in these two cities wash their own cars. Esso points out that a big part of this business is waiting for stations that get into the car washing business. That company is promoting the idea by publicity to dealers with the basic idea that now that everybody is driving an "old" car (by pre-war standards), it is all the more important to keep it looking spic-and-span. Many of that company's stations this year will feature "beauty treatments" for cars. The promotion says the treatments are inexpensive, and urges car owners to make appointments. It is pointed out to dealers that washing service leads to other sales, such as polishing, the sale of polishing cloths, and the like.

"At the Crossroads" reads the caption on one major company's dealer promotion, illustrating a junk yard. Below this the message reads: This is the turning point—this spring of 1944. Will cars turn left and end up in that purgatory of lost automobiles, the junk pile? Or will they turn right into our stations, where Care Saves Wear is practiced, patriotically and profitably?

Financial Reports

Gallagher Calls on U. S. To Draft World Oil Conservation Compact

NPN News Bureau

NEW YORK — An international oil conservation agreement with the U. S. taking the initiative in collaboration with other oil producing nations was recommended by R. W. Gallagher, president of the Standard Oil Co. (N.J.) in his letter to stockholders transmitting the company's annual report.

"If, after this war, any substantial part of the world is to enjoy a standard of living approaching that achieved in the U. S., world production of oil must be greatly increased," Mr. Gallagher wrote. "There are, we think, two principal problems. One is to find more oil, the other is to establish sound, world-wide conservation policies under law so that oil will not be taken from the ground wastefully."

Crude Oil Output up 36%

Declaring that governments have not been successful in finding new resources, but when competing with private companies have actually prevented discovery of new resources, he asserted that "the U. S. government should encourage American private enterprise, first by refraining from competition, and second by lending American enterprise diplomatic support where Americans are at a disadvantage in foreign countries by reason of foreign laws or practices."

Mr. Gallagher characterized 1943 as a year of great wartime achievements by his company, pointing out that the company and its affiliates increased domestic crude oil production by 36% over their previous peak, refined 20% more crude oil per day than in 1942, manufactured two and one-half times as much 100-octane gasoline for warplanes, made 50% more synthetic toluene for TNT and brought into successful production two butadiene plants for making raw material for synthetic rubber.

Consolidated net income for 1942 was $121,327,773, equivalent to $4.45 per share. In 1942 it was $81,809,835 or $3 per share.

Concerning crude oil reserves, Mr. Gallagher predicted that "once conditions are again favorable, we can look to additional discoveries of oil, not only in this country, but throughout the world."

Jobs Await All in Service

He expressed the management's confidence that the nation would never face a shortage in liquid petroleum products if conditions favorable to the discovery of oil and to the development of synthetic substitutes are encouraged.

The principal postwar problems of the company and its affiliates, Mr. Gallagher said, will be to re-employ and train thousands of men and women who have gone into the armed forces, reconstruct distribution and marketing facilities, convert wartime refining and manufacturing facilities, expand the world's known oil reserves in step with expanding worldwide need and reconstruct world transportation systems.

The company expects peacetime demand for petroleum products to be ample, though temporarily smaller than before the war. The company and its affiliates expect to be able to retain all current personnel, and all men and women who have gone into the armed services have been told that jobs will be waiting for them when they return.

Mid-Continent Nets $6,588,617

Special to NPN

BALTIMORE—Consolidated net profit of Mid-Continent Petroleum Corp. and its subsidiaries for 1943, after all charges, reserves and provision for federal and state taxes on income, amounted to $6,588,617, equivalent to $3.53 per share, compared with $6,112,158, or $3.29 per share, in 1942.

Gross sales amounted to $56,809,225, compared with $48,679,426 for 1942. Net profit before federal and state taxes on income increased from $9,319,381, or $5.02 per share, in 1942 to $10,614,428, or $5.71 per share, in 1943.

Indiana Standard Net Up

NPN News Bureau

CHICAGO — Gross income of Standard Oil Co. (Indiana) totaled $506,173,225 for 1943, Edward G. Seubert, president, announced. Consolidated net earnings of the company and subsidiaries in 43 states on all phases of operations amounted to $3.31 a share for the year as compared to net of $2.89 a share for 1942 and $3.17 for 1941.

Net income for the company for the year amounted to $50,591,371. Net of 1942 was $44,183,893 with the increase for 1943 explained by Mr. Seubert in view of gasoline rationing and high taxes, as due principally to larger production and larger volume of sales handled in economical ways and to near absence of price cutting tactics previously prevalent in marketing of petroleum products.

Gulf Pays $3.23 Dividend

Special to NPN

PITTSBURGH—The annual financial statement of Gulf Oil Corp. and its subsidiary companies for 1943 shows that the consolidated net income amounted to $29,301,053, equivalent to $3.23 per share of capital stock outstanding, compared with $22,981,562, or $2.53 per share, in 1942.

Reflecting the increase in sales of Gulf products arising out of the war demands, the company's gross operating income in 1943 rose to $431,761,284, an increase of 23.4% over the preceding year.

The company's total gross production of crude oil in 1943 was 85,796,588 bbls. The net production was 73,098,539 bbls. This compares with gross production in 1942 of 76,528,100 bbls and net production of 66,459,261 bbls.

Humble Boosts Net Income

HOUSTON—Consolidated net income of $45,711,511 for 1943 was reported by Humble Oil and Refining Co. as compared with $29,243,303 in 1942. Dividend payments in 1943 totaled $22,469,600 as against $17,975,680 in the previous year.

The report also showed that the company's capital stock was increased from 9,000,000 to 18,000,000 shares, in keeping with a charter amendment approved by stockholders on Nov. 22, 1943.

Earnings last year were equivalent to $5.08 per share on shares outstanding Jan. 1, 1943 to $2.54 on the new stocks. Dividends per share amounted to $2.50 on old stock, or $1.25 on the stock outstanding Dec. 31, 1943.

Amerada Shares Earn $6.06

Special to NPN

NEW YORK—The Amerada Petroleum Corp.'s net profit for 1943, after deducting all charges and reserves, including all intangible drilling costs, amounted to $4,781,770, or $6.06 per share, which compares with a profit of $3,271,885, or $4.15 per share earned in

1942. The number of net outstanding shares remained unchanged at 788,675. Dividends at the annual rate of $2 per share were paid for the 18th consecutive year. As a result of improved earnings, due to increased production of both oil and gas, the directors have increased the quarterly dividend beginning with the payment made on Jan. 31, 1944, to 75 cents, or to an annual rate of $3 per share.

Oil Sources Adequate in U. S. For Future, J. A. Brown Says

NPN News Bureau

NEW YORK—Taking issue with those who believe that American oil resources are inadequate for the future, John A. Brown, president of the Socony-Vacuum Oil Co., Inc., stated in his annual report to stockholders that present crude reserves form the smallest part of the future oil supply.

When other sources of oil are included, such as probable discoveries, natural gas, shale and coal, Mr. Brown said: "We have in this country sufficient future supplies to carry on indefinitely in accordance with our high living standards and to provide for our national defense in the future."

Mr. Brown pointed out that these domestic supplies can be supplemented at any time by imports of foreign crude. He stated that oil exploration abroad has been successfully carried out by private American enterprise, and that the government should not seek to participate in these foreign developments in any proprietary form.

"The past action of other powerful nations in taking proprietary rights in natural resources in other countries should not be imitated by us," Mr. Brown declared. "The future peace of the world will be less hazardous if these nations dispose of ownership to their citizens and if no nation adopts such policy in the future."

Socony-Vacuum's net earnings for 1943 were $35,944,983, the annual report showed. The earnings are equivalent to $1.15 per share, as compared with total earnings in 1942 of $30,808,397, or 99 cents per share.

McColl, Frontenac Net $836,500

Special to NPN

OTTAWA, Can.—McColl Frontenac Oil Co. Ltd., in 1943 had net earnings of 42 cents a share, as against 57 cents a share the previous year. Net earnings expressed in dollars were $836,500. Crude oil purchased during the year totaled 6,429,291 barrels, and inventory at the year-end was about the same as at the end of 1942. Refinery capacity at both Montreal and Toronto was increased. Taxes in the year amounted to $1,981,000, which President J. M. Pritchard states was 67% of profit before taxes.

SOUTHEASTERN OIL

Where There's Vision There's Progress

Just as past experience has prepared us to give exceptional service during the present war emergency, so is the present preparing Southeastern Oil for the future.

We are looking forward to a great future beyond victory because we are an organization of young men, with vision, and we are planning now for the golden age ahead—a time more potentially rich than any the world has ever known.

While the facilities of Southeastern are now devoted principally to serving the Armed Forces, we are thinking and working on plans for the future . . . plans for efficient distribution and marketing of petroleum products . . . plans that will assure exceptional service for the petroleum marketers of the Southeastern Atlantic seaboard.

In many of the new and better things that America's oil industry is planning for the future, Southeastern is preparing to have an important place.

SOUTHEASTERN OIL
and affiliates
Southeastern Oil Co., Southeastern Petroleum Corp.
★ Southeastern de Mexico ★
General Office
Graham Building — Jacksonville, Florida
OFFICES
JACKSONVILLE—WILMINGTON—WASHINGTON
NEW YORK—MEXICO CITY

Impossible to Replace Stocks at Current Prices, Taylor Asserts

NPN News Bureau

LOS ANGELES — The inventories U. S. had on hand at the beginning of the war were acquired during years when production costs were much lower than at present. Today's costs of production and operation are so high that it will be impossible to replace the stocks at the prices for which they are being sold. This was the sentiment expressed by Reese H. Taylor, president of the Union Oil Co. of California, in his annual message to shareholders.

Mr. Taylor said that the bulk of our underground reserves of crude oil were discovered and developed during low cost periods. The rapid liquidation of these low cost stocks was one of the contributing factors to the rise of Union Oil profits during 1943.

However, Mr. Taylor said, the fallacy of the popular argument that the profits of oil companies during the past two or three years does not justify any increase in the price of their products, lies in the fact that low cost reserves both above and below ground are being depleted to supply current demands. The experience of the industry, in production and exploration, definitely indicates that to replace these reserves will cost more than current ceiling prices permit.

On the subject of secondary recovery the Union Oil president said:

"Following a year of intensive study, we initiated California's first waterflooding project just two weeks ago. While this project is confined to a small sand body, on an experimental basis only, it is hoped to gain enough knowledge from it to start full scale operations at a later date.

"No one knows what the application of secondary recovery methods in California will mean to actual crude oil recovery. But some idea of the possibilities may be gained when it is realized that present production methods only recover around 30% of the original oil content of the average field.

"The study of secondary recovery methods was supplemented by intensive research in oil shale and tar sand processes.

"Separation of natural gas fractions was another research project designed to augment Union Oil's supply of crude oil."

In conclusion, Mr. Taylor stated that even though the crude oil reserves are being depleted rapidly in filling the demand of the military for petroleum products, there is no cause for alarm or pessimism about the future.

"If private enterprise is accorded the opportunity and incentive, with a minimum of government restriction, there is no reason to fear a scarcity of petroleum products.

"Periodically, since oil was first discovered in Pennsylvania, the industry has faced problems that looked almost insurmountable. But in every case American ingenuity and American enterprise have not only solved them, but gone on to greater accomplishments."

Gasoline Consumption by States, November, 1943

(American Petroleum Institute figures in gallons, 000 omitted)

	Month of Nov. 1943	Month of Nov. 1942	% Change
Alabama	22,953	30,180	—23.95
Arizona	12,251	13,120	— 6.62
Arkansas	16,373	18,130	— 9.69
California	256,877	192,486	+33.45
*Colorado	.....	.....	.....
Connecticut	23,399	25,721	— 9.03
Delaware	4,123	4,070	+ 1.30
District of Columbia	9,026	10,913	—17.29
Florida	32,339	38,610	—16.24
Georgia	28,255	31,854	—11.30
Idaho	8,397	11,122	—24.50
Illinois	100,494	135,822	—26.01
Indiana	56,285	67,136	—16.16
Iowa	40,732	51,179	—20.41
Kansas	31,194	44,716	—30.24
Kentucky	20,456	23,765	—13.92
Louisiana	23,681	32,386	—26.88
Maine	9,825	10,383	— 5.37
Maryland	23,509	25,077	— 6.25
Massachusetts	44,669	46,401	— 3.73
Michigan	79,706	102,748	—22.43
Minnesota	33,140	48,140	—31.16
Mississippi	16,792	23,170	—27.53
Missouri	45,218	56,255	—19.62
Montana	8,274	11,221	—26.26
Nebraska	16,517	23,205	—28.82
Nevada	5,017	5,098	— 1.59
New Hampshire	4,877	5,767	—15.43
New Jersey	61,304	55,479	+10.50
New Mexico	8,840	9,443	— 6.39
New York	115,334	123,423	— 6.55
North Carolina	33,365	34,656	— 3.73
North Dakota	10,639	13,512	—21.26
Ohio	108,449	129,559	—16.29
*Oklahoma	.....	.....	.....
Oregon	20,863	25,615	—18.55
Pennsylvania	94,647	115,616	—18.14
Rhode Island	9,022	8,950	+ 0.81
South Carolina	16,327	16,917	— 3.49
South Dakota	9,408	11,227	—16.20
Tennessee	30,305	34,807	—12.93
Texas	260,539	177,844	+46.50
Utah	8,851	11,096	—20.23
Vermont	3,726	4,067	— 8.38
Virginia	32,086	33,469	— 4.13
Washington	32,211	40,532	—20.53
West Virginia	14,510	15,176	— 4.39
Wisconsin	40,186	51,028	—21.25
Wyoming	4,656	5,672	—17.91
Total	1,889,647	2,006,763	— 5.84
Daily Average	63,087	.....	.....

Percentage Change in Daily Average —5.84.

*Not available at time of publication.

Consumption in Colorado during October was 22,895,000 gal.; in Oklahoma, 34,610,000 gal.

34 More Service Stations In Operation on Coast

NPN News Bureau

LOS ANGELES—The number of service stations in operation on the Pacific Coast increased by 34 during the month of March, according to the regular monthly report issued by the Fifth District Distribution and Marketing Committee.

The report reveals that in the five western states of California, Washington, Oregon, Arizona and Nevada a total of 5315 stations were closed as of April 1. This compares with 5349 on March 1 and 5221 on February 1.

A breakdown by states of the number of stations closed on April 1 as compared with March 1 follows: California, 3418 against 3438; Oregon, 561 against 580; Washington, 895 against 892; Arizona, 313 against 315, and Nevada, 128 against 124.

As for bulk plants the report shows a total of 83 closed as of April 1 compared with 80 on March 1. Of the total, 53 of the closed bulk plants were in California.

Rubber Goods Dept. Expanded

Special to NPN

LOS ANGELES—Expanding its facilities for manufacture of mechanical rubber goods, the Goodyear Tire & Rubber Co. last week announced that production of hose and certain other products has been started in the company's Los Angeles plant.

The first product of the expanded department was a length of rubber suction hose of special synthetic rubber construction for use in the recently-opened synthetic rubber plant in Los Angeles.

HAVE YOU READ THESE IMPORTANT OIL LAWS?

These are the 6 most important War-Oil Regulations . . . Do you and your employees KNOW THEM?

To PROTECT YOUR BUSINESS AND YOURSELF, you and your employes SHOULD KNOW the regulations that govern your business. Ignorance and misunderstanding are no defense before the law, even though it is quite human these days of thousands of war orders applying to oil alone, to make slips on these rules. Nevertheless, human or no, the government ruling agencies will not overlook mistakes, therefore why invite trouble? . . . KNOW YOUR OIL LAWS!

Each of the above booklets contains the full text of one of these 6 important oil laws . . . If you will supply these booklets to all of your key employes who need to know these laws to carry on their daily work, such as, for example, your Officers, Division and Branch Managers, Bulk Plant Managers, Salesmen, Station Supervisors and Service Station Managers as well as Dealers and Truck and Transport Drivers, they will more thoroughly understand the laws governing your business and through that understanding be able to COMPLY with them more readily.

Begin today to PROTECT YOUR BUSINESS AND YOURSELF by sending for the booklets in the right-hand column that pertain to YOUR business . . . Here's how to order:

TEAR OUT THIS PAGE AND MAIL IT BACK *NOW!*

Jot down the number of booklets you want on each of these Important War-Oil Regulations, in the space provided therefor beside each Booklet description... Then sign your name and fill in your address on the coupon below and mail this sheet back TODAY for immediate delivery!—Send no money—we'll bill you later.

Pick Out the Booklets That Cover Your Business

No. Needed

____BOOKLET 1—Prices on Fuel Oil, Gasoline, Liquefied Petroleum Gas and Solvents. Known as "Maximum Price Regulation 88." 90 pages. Single Copy Price $1.00. Quantity Rates: 2 to 5—90c, 6 to 10—80c, 11 to 25—70c, 26 to 50—60c, 51 to 100—50c, 101 to 250—45c, 251 to 500—40c, 501 and over—30c.

____BOOKLET 2—Latest revision of Retail Price Order on Motor Fuel, Motor Lubricating Oil, Greases, Kerosene, Prime White Distillate, Nos. 1 and 2 Fuel Oil, Range Oil and Naphthas. Known as "Revised Maximum Price Regulation 137." 20 pages. Rates: Single Copies to 5—50c, 6 to 10—45c, 11 to 25—40c, 26 to 50—35c, 51 to 100—30c, 101 to 250—28c, 251 to 500—25c, 501 and over—23c.

____BOOKLET 3—Crude Petroleum and Natural Gas Prices, including the 10 Amendments. Known as "Maximum Price Regulation 436." 24 pages. Single Copies to 5—50c, 6 to 10—45c, 11 to 25—40c, 26 to 50—35c, 51 to 100—30c, 101 to 250—28c, 251 to 500—25c, 501 and over—23c.

____BOOKLET 4—Bulk ceiling prices for Motor Oils, including Aviation Oils, Stock Oils (neutrals, bright stocks, steam refined and other stock oils), Greases, Industrial Oils, Petroleum Sulphonates, Mineral Oil Polymers, and any other fraction of crude petroleum which is sold as a source of any of the foregoing commodities. Known as "Maximum Price Regulation 510." 24 pages. Single Copies to 5—50c, 6 to 10—45c, 11 to 25—40c, 26 to 50—35c, 51 to 100—30c, 101 to 250—28c, 251 to 500—25c, 501 and over—23c.

____BOOKLET 5—Gasoline Rationing, including Am. No. 114, known as "Ration Order 5C." 204 pages. Single Copy $1.00. Quantity Rates: 2 to 5—90c, 6 to 10—85c, 11 to 25—80c, 26 to 50—70c, 51 to 100—60c, 101 to 250—50c, 251 to 500—45c, 501 and over—40c.

____BOOKLET 6—Fuel Oil Rationing, including all 95 amendments and omitting the obsolete material. Known as "Revised Ration Order No. 11." 175 pages. Single Copy $1.25. Quantity Rates: 2 to 5—$1.15, 6 to 10—$1.00, 11 to 25—90c, 26 to 50—85c, 51 to 100—80c, 101 to 250—70c, 251 to 500—60c, 501 and over—50c.

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Supreme Court Sustains OPA Price Control Law In Regard to Filing Objections to Orders

By Elwin E. Hadlick

JOHN Q. PUBLIC is inclined to look upon a decision of the U. S. Supreme Court as the final and definite word on any subject with which it concerns itself. On occasions which are becoming too frequent, the court has been upsetting traditions. One of the judges recently remarked in a dissenting opinion that the decisions of the Supreme Court were getting to be like a railroad ticket good for use only on a certain train on a certain day.

Mr. Hadlick

Be that as it may, we are all bound by the current opinion of the court whatever it happens to be. Right now while serious considerations are being given to rewriting of the Emergency Price Control Act (the law under which OPA receives its authority to fix prices), pronouncements of the Supreme Court concerning the law must be carefully noted. In considering OPA's price fixing authority and its procedure thereunder, it is necessary to forget all about rationing and procedures for rationing order enforcement. In rationing neither the authority nor the procedure stems directly from Congress.

Law Not Taken Seriously

Price control activities arise out of the Emergency Price Control Act. The Supreme Court in the case of Yakus vs. U. S., made some important pronouncements, at least one of which may serve to bring to the attention of many in the business world for the first time, a vital provision of the price control law.

The law provides that objections to any provision of a regulation or order must be made to OPA within 60 days after the date of issuance (or thereafter within 60 days after later grounds for objections arise). The objection must be supported by affidavits or other written evidence. There is provision for appeal to an Emergency Court of Appeals in case the administrator decides against the objecting party. If one loses in that court he at least has the right to ask the Supreme Court to review the case.

That provision hasn't been taken too seriously. Many business men have felt that if they were called on the carpet for violation of price regulation, they would always be in position to raise a question concerning the constitutionality of the particular order. The law says otherwise, and the Supreme Court has now sustained the law at least insofar as a criminal prosecution is concerned.

In other words, the Supreme Court has now said that in a criminal prosecution for violation of a price control regulation, the defendant may not raise any question as to the validity of a maximum price regulation. The court reached this conclusion on the basis that the provisions of the law providing for the filing of objections with the administrator are adequate.

This means that if any question of the constitutionality of a price regulation of OPA is to be raised, it must be raised by objections filed with the administrator within the period provided by the law.

This is the seventh in a series of articles by Mr. Hadlick to assist oil men to bring about full compliance on the part of themselves, their employes and the consuming public with all government regulations concerning oil.

Mr. Hadlick is a prominent member of the Minnesota Bar and for many years has been president and chief executive officer of the Northwest Petroleum Assn. which represents marketers in Minnesota and North Dakota. He is well qualified to advise management on its responsibilities under the regulations and also to point out benefits that may be obtained and which might otherwise be overlooked by busy executives.

In this week's article Mr. Hadlick discusses a vital provision of the Price Control Act as it pertains to filing of objections to a regulation or order.

Specific Price Problems

The court decided a number of other things in that particular case, but they need not be touched on here except in one respect. The point above covered was not the principal one in the case, though it is the most interesting from a practical point of view. Legalistically speaking, the principal part of the decision of the court was that in which it was found that the Emergency Price Control Act contains a constitutional delegation of power to the price administrator.

A neat price situation is presented in connection with some of the specific prices which OPA has set. A specific price is a definite fixed price for a commodity at a particular point under specific conditions of delivery. OPA has, for example, had specific prices on some petroleum products for delivery f.o.b. refineries or terminals; it has in other cases set specific prices for delivery to the customer. In most of such cases OPA has fixed a ceiling different than the ceilings of some sellers determined under other provisions of the price regulation.

The question involved is, to what extent does the setting of a specific price control, interfere with, or affect ceiling prices otherwise determined under other provisions of the regulation.

The specific price replaces the ceiling price determined by other provisions of the regulation for a particular product at a particular point and according to a particular method of delivery.

OPA hesitated for a long time as to what, if any, other effect the setting of a specific price might have. For example, if a seller had a ceiling price for a product delivered to the customer which was lower than the specific f.o.b price later fixed by OPA, which price controls and to what extent? Most people in industry and some in OPA thought that in such a situation the maximum price which could be charged to the customer on a delivered basis was the combination of the specific price plus the applicable delivery charges. Under such thinking an operator could continue on a delivered basis, charging a price which represented the f.ob. price plus transportation, the result being a delivered price higher than the operator's original ceiling.

Applies to Type of Sale

OPA has now said that such thinking is erroneous. The specific price applies only on the type of sale for which it is set. If a specific f.o.b. price will give a seller a larger net-back than a delivered price determined by the other rules there is nothing to prevent him from switching from a delivered basis to an f.o.b. basis. He will run into some regulation on the subject in some price orders. The new price regulation 88 provides that a seller who on the last sale prior to Jan. 15, 1944, sold a particular petroleum product to a purchaser who is a reseller on a delivered price basis at a given point and who thereafter sells such a reseller on an f.o.b shipping point price basis shall report such fact to the regional office of the Office of Price Administration within 10 days after the date such sale is made, if (but only if) the effect of selling on an f.o.b. shipping point price basis is to increase the laid-down cost to the reseller above the seller's maximum delivered price to such reseller.

REGULATIONS

Digests of Regulations Issued Weekly Regarding Oil and Oil Equipment . . Reports of Prospective Regulations and Amendments . . Actions of Industry Committees and Meetings . . Editorial Comment, Interpretation.

Index of Week's War-Oil Orders

CODE: AO—Administrative Order; CMP—Controlled Materials Plan; D—Directive; FDO—Food Distribution Order; GMPR—General Maximum Price Regulation; GO—General Order; Interp.—Interpretation; L—Limitation Order; M—Conservation Order; MPR—Maximum Price Regulation; P—Preference Rating Order; PAO—Petroleum Administrative Order; Pri. Reg.—Priorities Regulation; Proc. Reg.—Procedural Regulation; PS—Price Schedule; RO—Ration Order; RPS—Revised Price Schedule; SO—Supplementary Order; SR—Supplementary Regulation.

(Issued April 22-29, 1944)

PAW—Petroleum Administration for War

Priorities Circular 8, as am. 4-15-44—Relation of P-98-b to U-2 and U-3

District 1 Letter to Suppliers—Checking of estimates of non-highway farm sales

War Emergency Pipe Lines Operating Schedule 3—Product deliveries and sales at Baytown and Beaumont, Tex.

War Emergency Pipe Lines Operating Schedule 16—Crude deliveries and sales at Longview, Tex.

OPA—Office of Price Administration

Prices

GMPR—Order 639 under § 1499.3(b)—Ceilings for Gulf Electric-Motor and Penetrating Oil

MPR 88, Am. 6—Specific kerosine and fuel oil prices for N. H. and N. J.; Ohio, Md., Va. gasoline prices

Am. 7—Worcester, Mass., Area specific kerosine and fuel oil ceilings

Am. 8—Alaska excluded from MPR 88's jurisdiction; ceilings for transferees of a business.

MPR 131, Am. 1—Minor changes in camelback price order

MPR 134, Am. 15—Charges for overtime operation of equipment

RMPR 143—Wholesale ceilings for new tires and tubes

MPR 510, Am 2—Specific ceilings for Freedom Oil Co P.G.C.O.A. permit oils

MPR 528—Retail ceilings for new tires and tubes, used and recapped tires and tubes

Rationing

RO 5C, Am. 120—Deputy Admr. may issue order permitting acceptance of R coupons

Order 3—Licensed distributors in Kansas authorized to accept R coupons

Licensing Order 3, Am. 1—Clarification of term "dealer"

WPB—War Production Board

L-317, as am. 3-23-44—Restrictions on manufacture and use of fibre shipping containers

Direction 1—Acceptance of new fibre shipping containers

M-84, Am. 1 to 4-5-44 version—Wrapping or tying twine may be manufactured

M-293, as am. 4-21-44—Freezing of X product shipping schedules

ODT—Office of Defense Transportation

AO ODT 24—Uniform procedure for issuance of fuel oil permits for occupational use of vessels

Gen. Permit ODT 3, Revised-5A—Common carriers' small and specially-designed empty trucks exempt from registration requirements

Gen. Permit ODT 17-14A—Other motor carriers' small and specially-designed empty trucks exempt from registration requirements

Special Direction ODT 18A-3, Am. 1—Water-rail or rail-water-rail shipments

DSC—Defense Supplies Corporation

Reg. 5, as am. 4-10-44, including Schedules A, B, C, D—Compensation for crude shipments from Dists. 2, 3, and 4 to Dist. 2

ICC—Interstate Commerce Commission

Ex Parte MC-37—Determination of localities within which transportation is exempt from control of ICC Act, Part II

DEPARTMENT OF LABOR

WLD-22—Transportation of petroleum products by Des Moines company found to be "contracted for in prosecution of the War" (Case S-818)

WFA—War Food Administration

Redesignation and renumbering of orders—"War Food Orders" designates former Food Production and Distribution Orders

Digest of Week's War-Oil Orders

Petroleum Administration of War

RELATION OF P-98-b TO U-2 AND U-3—Pri. Circular 8, as am. 4-15—A petroleum operator maintaining private telephone, telegraph, or teletype lines and facilities is an operator under U-2 rather than under U-3, which formerly applied, and he may use a priority rating of AA-1 for up to $2,500 worth of MRO material for such facilities under P-98-b. Initial installations have $2,500 priorities material and $5,000 total material cost limitation. Otherwise application on Form 30 must be sent to Washington PAW. Issued 4-15.

CHECKING OF ESTIMATES OF NON-HIGHWAY FARM SALES—District 1 Letter to Suppliers—To assist suppliers in estimating non-highway farm sales, which are given preference under PAO 1 by requiring apportionment in full to them before distributing balance to other customers, PAW suggests that duplicate deposit slips be checked, showing itemization of all classes of coupons, such as E and R coupons, and coupons not transferred at a ration bank, which have been itemized on OPA Form 541, "Summary of Gasoline Coupons". By subtracting supplier's estimate of E and R sales made to non-farmers (operators of engines, bulldozers, etc.) net farm sales are obtained. A few suppliers will have to add the gallonage of those customers using over 960 gals. per month, who are issued ration banking deposit certificates, but these large users are few in District 1. Issued 4-21.

PETROLEUM PRODUCT DELIVERIES AND SALES TO WAR EMERGENCY PIPELINES, INC. AT BAYTOWN AND BEAUMONT, TEX., RECEIVING STATIONS—PAW Operating Schedule 3 (20-inch pipeline)—Pursuant to Petroleum Directive 73, final May schedule and tentative June and July, 1944, schedule set for petroleum products delivered and sold to War Emergency Pipelines, Inc., as agent for DSC. Listed are names of sellers, place of sale, kind and quantity of products to be delivered at easterly termini of pipeline system during each month. Balance of available capacity of 20-inch pipeline will be used for transportation of products required by departments and agencies of Federal Government. Issued 4-15.

CRUDE DELIVERIES AND SALES TO WAR EMERGENCY PIPELINES, INC. AT LONGVIEW, TEX.—PAW Operating Schedule 16 (24-inch pipeline)—Pursuant to Petroleum Directive 63, final May schedule and tentative June and July schedule published for crude delivered and sold to War Emergency Pipelines, Inc., as agent for DSC. Names of sellers and refinery and terminal purchasers are given, together with place of sale, grade and quantity of crude for each month. No regular movement of heating oil is scheduled for May, June, and July. Issued 4-22.

Office of Price Administration

CEILINGS FOR GULF ELECTRIC-MOTOR AND PENETRATING OIL—GMPR, Order 639 under § 1499.3(b)—These brands in 4-oz. bottles with spouts may be sold to consumers at 15c each, to dealers at $1.20 dozen list price, with from 5% to 20% discounts for quantity delivery. Jobbers' and retailers' prices also set, and Gulf is instructed to supply jobbers and dealers with special notice of these prices and of permitted discounts. A special notice to retailers must be placed in each packed case of bottles for the next 90 days. Issued 4-8, effective 4-10.

SPECIFIC KEROSINE AND FUEL OIL PRICES FOR N. H. AND N. J.; OHIO, MD., VA. GASOLINE CEILINGS—MPR 88, Am. 6—Additional 1.5c per gal. on small kerosine and No. 1 fuel oil deliveries in New Hampshire may be charged only on single lot deliveries under 25 gals., not 100 gals., as originally specified. 100 gal. provision for Nos. 2 and 3 fuel oil unchanged. Bayonne (Hudson County) and Essex County, N. J., kerosine and No. 1 fuel oil ceilings adjusted to conform to prevailing base period prices. Two Newark bulk plant operators receiving supplies by truck granted slightly higher resale ceiling on Nos. 2, 3, and 4 distillate fuel oil than those receiving supplies by barge. In no case are ceilings increased above those prevailing on 11-16-43, date of pertinent amendment to old RPS 88. Only sales to consumers are governed by Sohio's 8.375 regular gasoline price quoted in 10-8-41 National Petroleum News. Tank car and transport truck prices to resellers are to be determined under other sections of Article V, which will permit a price approximating the 9.5c tank wagon price prevailing in October, 1941. Effective as of 2-19-44, there may be added to tank wagon gasoline deliveries in Maryland and Virginia communities where sellers were absorbing part of the state taxes, at end of 1941, to approximate Washington total selling prices, a sum equalling amount of tax absorbed, or .5c gal., whichever is lower. Issued 4-24, effective 4-29.

WORCESTER, MASS., AREA SPECIFIC KEROSINE AND FUEL OIL CEILINGS—Tank wagon kerosine and No. 1 fuel oil ceilings to various buyers in varying quantities range from 8.3c to 12.1c gal.; Nos. 2, 3, and 4 distillate fuel oil from 7.8c to 9.8c gal. Issued 4-27, effective 5-2.

ALASKA AND CANAL ZONE EXCLUDED FROM MPR 88's JURISDICTION; CEILINGS FOR TRANSFEREES OF A BUSINESS—MPR 88, Am. 8—Deadline for transfers of businesses or stocks in trade, after which transferor's prices must be continued by transferee set at Feb. 11, 1942, instead of Oct. 15, 1941. Marketers in areas covered by Table II of Article III permitted mark-up over refiners' ceilings, as well as in those areas covered by Table I. Issued 5-2, effective 5-8.

MINOR CHANGES IN CAMELBACK PRICE ORDER—MPR 131, Am. 1—Any seller of predesigned camelback is granted the 8c lb. differential over ordinary type, rather than only the Webster Rubber Co. of Warren, O. Issued 4-24, effective 4-29.

CHARGES FOR OVERTIME OPERATION OF EQUIPMENT—MPR 134, Am. 15—Suppliers of service who must pay overtime wages because of overtime operation of equipment may add to their charge the dollar amount of so much of the excess of actual overtime over actual straight time wages as is paid the operators or operating crews of the equipment, plus payroll taxes and insurance, but not including markup. Issued 4-24, effective 4-29.

WHOLESALE CEILINGS FOR NEW TIRES

OIL-LAW-Gram Service

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Due care and judgment have been taken in preparing and publishing these digests and in reproducing the original texts but the publisher does not warrant their absolute legal completeness nor accuracy. Important decisions by the reader should be made only after careful study of complete texts.

AND TUBES—RMPR 143—Revised price order replaces former MPR 143. Issued 4-20, effective 5-1 in U. S. and 6-14 in territories and possessions.

SPECIFIC PRICES FOR FREEDOM OIL CO. P.G.C.O.A. PERMIT OILS—MPR 510, Am. 2—Prices to wholesalers in full drums, drums extra, ex taxes for S.A.E. No. 70 set at 29c and for No. 10 at 32c, with in-between numbers ranging between these two prices. Customary differential for quart prices. Issued 5-2, effective 5-8.

RETAIL CEILINGS FOR NEW TIRES AND TUBES; USED AND RECAPPED TIRE AND TUBE CEILINGS—MPR 528—New price order replaces former RPS 63, 66, MPR 107 and MPR 165's coverage of vulcanized tire repairs and all tube repairs. Issued 4-20, effective 5-1 in U. S., 6-14 in territories and possessions.

DEPUTY ADMINISTRATOR MAY ISSUE ORDER PERMITTING ACCEPTANCE OF R COUPONS—RO 5C, Am. 120—Acceptance of R coupons for bulk transfers by specified dealers or licensed distributors may be authorized by Deputy Rationing Administrator if he finds that they are so regulated by state law that such acceptance of Class R coupons will not facilitate unlawful acquisition. Issued and effective 4-21.

LICENSED DISTRIBUTORS IN KANSAS AUTHORIZED TO ACCEPT CLASS R COUPONS—RO 5C, Order 3—Pursuant to Am. 120, *see above*, Kansas distributors licensed to make tax-exempt gasoline sales may accept Class R coupons for such sales when made in 40-gal. or larger quantities. Issued and effective 4-21.

CLARIFICATION OF TERM "DEALER"—Licensing Order 3, Am. 1—Manufacturers who sell any commodities to which this order is applicable, as well as auctioneers, and those who purchase for resale second-hand machine tools, extras, second-hand machines or parts are included in term "dealer". Issued 4-10, effective 4-15.

War Production Board

RESTRICTIONS ON MANUFACTURE AND USE OF FIBRE SHIPPING CONTAINERS—L-317, as am. 3-23-44—Carlining prohibited, except for door-blocking. Any user may use for the originally-intended purpose new containers in his possession or in transit to him by 10-11-43, subject to quota restrictions. Issued 3-23.

ACCEPTANCE OF NEW FIBRE SHIPPING CONTAINERS—L-317, Direction 1—No one may place orders for or accept fibre shipping containers in excess of permitted inventory, and all persons must cancel or postpone all outstanding orders in excess of permitted amount. Issued 4-13.

WRAPPING OR TYING TWINE MAY BE MANUFACTURED—M-84, Am. 1 to 4-5-44 version—Issued 4-21.

FREEZING OF X PRODUCT SHIPPING SCHEDULES — M-293, as am. 4-21-44 — Schedules of manufacturers filing schedules automatically frozen on date filed, under Pri. Reg. 18, for shipments to be made during specified period beginning on first day of month after schedule is filed. Unfiled schedules are frozen for 2-month periods at close of business on regular date for filing for unexcused manufacturers, and on same day of each month after that, for period beginning first day of following month. Issued 4-21.

Office of Defense Transportation

UNIFORM PROCEDURE FOR ISSUANCE OF FUEL OIL PERMITS FOR OCCUPATIONAL USE OF VESSELS—AO ODT 24—Asst. Director in Charge of Water Transport may execute and issue in his discretion permits concerning rationed fuel oil, No. 5 or 6, or Bunker "C" only, having 20° or below API gravity, for occupational use of boats for pleasure cruising, guiding, fishing, and sightseeing parties, as mentioned in Revised RO 11. A copy of application to be filed with OPA should be filed with ODT Asst. Director of Water Transport, Washington. He may issue permit if he determines that such operation will not impede the war effort either in use of fuel oil or manpower. Issued and effective 4-22.

COMMON CARRIERS' SMALL AND SPECIALLY-DESIGNED EMPTY TRUCKS EXEMPT FROM REGISTRATION REQUIREMENTS—General Permit ODT 3, Revised-5A—Issued and effective 4-25, replaces General Permit ODT 3 Revised-5.

OTHER MOTOR CARRIERS' SMALL AND SPECIALLY DESIGNED EMPTY TRUCKS EXEMPT FROM REGISTRATION REQUIREMENTS—General Permit ODT 17-14A—Issued and effective 4-25, replaces General Permit ODT 17-14.

WATER-RAIL OR RAIL-WATER-RAIL SHIPMENTS—Special Direction ODT 18A-3, Am. 1—Loading to the extent shown in any special direction or general permit issued pursuant to the provisions of § 500.73 of GO ODT 18A, as amended, is added to the other 3 permitted methods of calculating loading requirements. Issued and effective 4-24.

Defense Supplies Corp.

COMPENSATION FOR CRUDE SHIPMENTS FROM DISTRICTS 2, 3, AND 4 TO DISTRICT 2—DSC 5, as am. 4-10-44—Shipments from points of origin in Dist. 2 and 4 added to former coverage of DSC 5. "Crude Producing Areas" No. 10, 11, and 12 are defined, listing affected counties in Texas and Louisiana. Schedules B, C, and D, are newly added. B covers compensation on crude from West Texas transported through Stanolind Pipeline Co.'s pipeline to Cushing, Okla., and crude from Dist. 4 to refining points in Dist. 2. C covers compensation on rail movements of crude from Dist. 4 to refining points in Dist. 2. D covers compensation on barge movements of crude from Dist. 3 to points in Dist. 2. Issued 4-20-44, effective 12-4-43.

Interstate Commerce Commission

INVESTIGATION AS TO LOCALITIES WITHIN WHICH TRANSPORTATION IS EXEMPT FROM CONTROL OF ICC ACT, PART II—ICC Ex Parte MC-37—Examiner ordered to prepare a report on this matter. Copies to be issued in this proceeding may be obtained from ICC, Washington, D. C. Issued 3-31, filed 4-11.

Department of Labor

TRANSPORTATION OF PETROLEUM PRODUCTS BY DES MOINES COMPANY FOUND TO BE "CONTRACTED FOR IN PROSECUTION OF THE WAR"—Finding 22 under War Labor Disputes Act by Secretary of Labor (Case S-818), concerning Deep Rock Oil Co., Des Moines, Ia.—Issued 4-7.

War Food Administration

DESIGNATION "WAR FOOD ORDERS" REPLACES TITLE "FOOD PRODUCTION AND DISTRIBUTION ORDERS"—FDO 35 (rapeseed oil) and FDO 42 (fats and oils) now designated War Food Orders 35 and 42. FPO 11 (pyrethrum) and FPO 13 (rotenone) now designated War Food Orders 46 and 49. Issued 4-20.

Midwest Marketing Manpower Surveys Bog Down Between PAW and WMC; Slow Action Resented

NPN News Bureau

CHICAGO — Marketing manpower surveys have been initiated in 92 counties in 11 states in the Middle West, and 53 of them in 10 states have been completed, approved by the manpower subcommittee and the distribution and marketing committee of Dist. 2, then passed to PAW for further action to obtain "locally needed" designations by War Manpower Commission. A check-up on the various surveys and a report on their status was made at the Dist. 2 D. & M. committee meeting last week, according to B. L. Majewski, committee chairman.

However, the industry generally is keenly disappointed because none of the surveys has yet resulted in a permanently "locally needed" declaration by WMC in any of the areas surveyed, and an effort is being made to determine the reason. The three agency plan—PAW-ODT-WMC—for retaining in the industry key men such as truck drivers, mechanics, bulk plant operators and office personnel was drawn up in July of last year (*See NPN July 14, p. 9*).

H. T. Ashton, Socony-Vacuum, St. Louis, is chairman of the Dist. 2 manpower subcommittee in direct charge of the surveys. It is understood that about a dozen more surveys are now completed or nearly finished.

Situation Serious

From the record of surveys completed and approved by this industry subcommittee and subsequently by the D. & M. Committee, it appears that the manpower situation in most areas is serious and the problem of retaining essential employes in urgent need of attention. However, there are a few areas where surveys have disclosed that the manpower difficulty is not yet sufficiently pressing to require a "locally needed" designation, and the Ashton subcommittee has declined to approve the surveys with that aim. Surveys in St. Clair and Bond Counties in Illinois and in Kay County, Oklahoma, failed to obtain subcommittee approval. In Nebraska, the Brown county survey was approved by the two industry committees and was certified by PAW, Dist. 2 office, but the PAW manpower committee in Washington did not concur, reversed the Dist. 2 decisions and declared that the "locally needed" designation was not required in Brown County.

A summary of the 92 surveys shows:

State	Completed	Working	Total
Illinois	22	x	22
Indiana	1	7	8
Iowa	3	12	15
Michigan	2	x	2
Minnesota	4	7	11
Missouri	x	4	4
Nebraska	5	4	9
Oklahoma	3	x	3
South Dakota	2	3	5
Tennessee	5	1	6
Wisconsin	6	1	7
Total	53	39	92

Surveys involve the status of approximately 8000 key employes. Of this number, 3024 were found vulnerable to military draft; 795 of them, or 26%, are

truck drivers subject to draft. Work week of the 8000 employes ranges from 48 to 63 hours with an average of 54 hours. Nine per cent are women employes; 54% are men under 18 years of age or over 38; 4% of the men are physically disqualified for draft and the remaining 33% vulnerable. Twenty-eight per cent of the men vulnerable are married and have children. It was pointed out that if half or any large percentage of the 795 truck drivers are inducted, distribution of petroleum products in many survey areas would seriously be disrupted.

In order that bulk plant operators in various counties where surveys have been requested may know the situation, the D. & M. committee released the information. In counties where surveys show as having been completed and recommended, a check-up by the D. & M. committee with the Dist. 2 PAW office reveals that they were certified to PAW, Washington. It is assumed that that office approved all of them with the exception of Brown County, Nebraska, referred to above as having been declined, or that they "are in the mill". After PAW approval at Washington, it is understood here, they are routed to WMC for matching with ODT report on compliance with "Luxury Order 37," then are supposed to receive WMC "locally needed" designation.

22 Surveys in Illinois

Twenty counties in Illinois with surveys completed and recommended are Monroe, Kankakee, Coles, Stephenson, Clay, LaSalle, DeKalb, Grundy, McHenry, Boone, Livingston, Ogle, Christian, Macon, Sangamon, Piatt, Tazewell, Cook, DuPage and Will. In St. Clair and Bond Counties surveys failed of approval.

In Indiana Marion County is the one shown as completed, and WMC some time ago voluntarily designated the following counties as "locally needed" on a temporary basis, with surveys now under way to confirm the situation and put it on a permanent basis, if proved: LaPorte, Stark, Pulaski, St. Joseph, Marshall, Elkhart, Kosciusko.

Iowa, completed and recommended: Sac, Buena Vista and Hamilton. Mills, Harrison and Pottawattomie Counties are on temporary "locally needed" basis, with confirming surveys now under way. Surveys are also being made in Emmet, Webster, Marshall, Adams, Iowa, Henry, Humboldt, Kossuth and Boon Counties.

Michigan, completed and recommended: Wayne and Oakland.

Minnesota, completed and recommended: Hennepin, Ramsey, Washington and Dakota. Surveys in progress in Carlton, Lake, St. Louis, Bellrami, Itasca, Lake of the Woods, Koochiching Counties.

Nebraska: Brown County failed of approval. Completed and recommended: Cherry, Sheridan, Adams. Douglas, Cass and Sarpy are on temporary "locally needed" with confirming surveys in progress, along with others in Gage and Pierce Counties.

Oklahoma: Kay County denied approval. Cleveland and McClain Counties completed and recommended.

South Dakota: Completed and recommended, Brown and Hutchinson Counties. Surveys in progress in Minnehaha, Davison and Spink.

Tennessee: Completed and recommended: Clay, Jackson, Overton, Pickett, Putnam. In progress: Montgomery.

Wisconsin: Completed and recommended: Winnebago, Sheboygan, Douglas, Brown, Outagomie, Manitowoc. In progress: Fond du Lac.

Missouri, in progress: Clark, Schuyler, Scotland and Knox.

A letter currently being sent by PAW Dist. 2 to distributors and jobbers, in areas which have been declared "locally needed" advises them that if the PAW office is to assist in deferments, they must have a letter explaining the experience, duties, marital and pre-Pearl Harbor father status of the employe, also a copy of Form 42A and copy of the employer's letter to the appeal board. Employes have 10 days after passing physical in which to make an appeal if desired, it was explained. No request for deferment by PAW should be made until the employe has taken his physical and has had his appeal denied. After that, the employe has minimum of 15 days notice before induction during which he can obtain PAW's assistance on deferment, according to the PAW letter.

WHERE THE FUEL GOES

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OWI

Uniform Wage Scale is Asked For Oil Well Rig Builders

Special to NPN

FORT WORTH — WLB has been asked by representatives of labor and oil drilling contractors to approve a uniform wage scale for oil well rig builders, with a top of $2.75 hourly for crew pushers down to $1.50 hourly for apprentices. Oil Workers International Union (C.I.O.) representatives from 27 states and contractors agreed on the scale in a session here.

If approved, the scale will go into effect in all oil producing states except California. A. R. Kinstley of Fort Worth, representative of Rig Drillers National Council, said that WMC has agreed to release rig builders now in war plants if such transfer is desired. Union officials said the higher scale would lure riggers from their present jobs.

OPA Collecting Data to Boost Jobber Margins on Fuel Oil

NPN Staff Special

DETROIT — OPA is now assembling data upon which to base recommendation for minimum jobber margins on fuel oil, Orville D. Judd, OPA petroleum price executive, told members of Detroit Fuel Oil Distributors Assn. at a meeting here April 25. He said that at present OPA does not know where to set a fair minimum margin, but that he was going to find out by examination of industry records. Compilation is now in progress and will be completed soon and fair margin established.

M. J. Vierling, OPA district fuel oil rationer, informed the meeting his office anticipated OPA approval of 10% additional fuel oil allotments this year for space heated homes where there are children under six years old. A proposal is also in the making to allow extra early summer and early fall rations for cottages in vacation areas of northern Michigan, he said. The industry advisory committee is also working toward 50 gal. minimum delivery on small hardship allocation and few end-of-season coupons.

Mr. Vierling recommended customer banking of coupons with distributors as matter of convenience and safety and to avoid call backs and acceptance by inexperienced truck drivers of coupons before validity dates.

Distributors anticipate a customer kickback on the Aug. 31 expiration of this season's coupons unless the public is fully advised and frequently reminded of earlier expiration date through summer advertising.

Orders Canada 'Gas' Coupons Marked on Face in Ink

Special to NPN

OTTAWA, Ont. — Under Canada's 1944-45 gasoline rationing regulations, motorists must write in ink the license numbers of their motor vehicles on the face of each gasoline coupon in their possession, the Munitions and Supply Department has announced.

The new regulations are designed to prevent illegal use of gasoline, according to Munitions Minister Howe. The order, issued by Oil Controller G. R. Cottrelle, provides that no unauthorized person shall at any time have a loose coupon in his possession.

Motorists are prohibited from obtaining and dealers from selling graded gasoline unless the vehicle operator hands ration book to dealer so that dealer himself may detach the correct number of coupons. Coupons must be detached before any gasoline is put into customer's tank.

TANHAM LEADS INDUSTRY GROUP IN WLB FIGHT

(*Continued from p. 7*)

fluence among all Regional War Labor Boards.

"8. The board, in effect, is legislating and thereby undertaking what is the function solely of Congress.

"9. The board's proposed policy tends inevitably toward a labor monopoly.

"10. There is no connection, as the majority opinion suggests, between union maintenance and the wage stabilization policy. The record of the board proves that wage adjustments occur regardless of union maintenance. All workers, whether organized or unorganized, are subject to the same rules of stabilization.

Say Employes Not Bound

"11. To order union maintenance in a situation where evidence indicates that it will disturb existing amicable relationships between employer and employes, as is the case here, is contrary to the duty of this board, which is to settle not to cause labor disputes.

"12. In this case, the majority has reversed its own precedent established in the H. D. Hudson Manufacturing Co. case, (No. AR-306 (3358-A) June 18, 1943.)"

Labor members, concurring with the public members, stated, in part, in their opinion, that "the dissent so uses the term closed shop, union shop, and union maintenance as to give the impression they are all the same. This confusion is further confronted by indiscriminate reference to assorted kinds of rights and 'what are we fighting for.'

"All of this is merely an attempt, surely futile at this late stage, to conceal the fact that under a maintenance of membership clause no employe is required to join a union, and anyone already a member who wants to resign has ample time, namely 15 days, to do so before the provision takes effect.

"Thereafter, the maintenance clause applies only to those who have voluntarily elected to be bound by it. No amount of ranting can obscure the fact that the compulsion involved in this situation is no more illegal or unconstitutional than that in any other case in which a man who freely makes a contract is obliged to abide by it."

Mr. Tanham, major spokesman for the industry members in the case, has been associated with The Texas Co. for 25 years, starting as a stenographer in the executive offices in New York.

After serving as senior clerk and later executive assistant in the general domestic sales department, he was appointed assistant to the vice president in charge of domestic sales in 1928 and was made assistant to the company president five years later. He was elected a vice president in 1941.

PAW Materials Chief Hopeful on Outlook

NPN News Bureau

WASHINGTON — In report to P.I.W.C.'s production committee May 2, PAW Materials Director Parsons reported that, although there is a definite downward trend now indicated for third quarter due to shortages of manpower and facilities, it is believed sufficient materials can be made available for presently proposed third quarter oil production program.

It is now estimated, Parsons said, that total steel casting production will be about 5% less in third quarter than second quarter. Maximum facilities available for production of oil country tubular goods casing, tubing, and drill pipe for petroleum operations is about 285,000 tons quarterly, of which approximately 50,000 tons could be alloy steel in form of N-80 casing and tubing, grade E, and premium brands of drill pipe.

During first quarter of year, rolling mills fabricated and delivered 279,650 tons and, in view of importance of petroleum program, Parsons said, "We believe it possible to obtain a similar amount in second and third quarters."

During first quarter of year, steel mills fabricated and delivered 17,600 tons of drill pipe. Figure will be about same for second quarter. In view of expected manpower shortage, there may be some downward trend during third quarter, Parsons said, pointing out, however, that present production of 17,600 tons per quarter represents about 2,000,000 ft. of drill pipe, which is more than is being expended. "It is believed," he added, "that supply will be close to demand by the end of the third quarter. This is the most optimistic prediction we can make at this time, and any change would be downward."

Highlights of Report

Other highlights of Parsons' materials report to production committee follow:

Backlog of tool joint orders totals about 220,000, with present production approximately 7,500 weekly but with additional facilities being installed, weekly production capacity should be increased to 8,500 by end of May.

There is definite shortage in rock bits, and unless manufacturers given further relief by cancellation of army and navy contracts, no relief seen in immediate future.

While there are no definite figures as to extent of reduction in copper, there will be definite cut in third quarter compared with second quarter.

Aluminum is expected to be available to meet requirements for third quarter.

Among critical components, most severe shortage has been internal combustion engines, but the time is rapidly approaching when enough engines will be scheduled to fill petroleum requirements.

Truck survey initiated by PAW a few weeks ago, and now in progress in production branch, will be completed during next two weeks to determine number of trucks in operation. Survey will show usable trucks in storage, number of new trucks required by July 1, and number required for 1944.

DSC Absorbs Excess Shipping Costs from Dists. 3 and 4

NPN News Bureau

WASHINGTON — Another barrier to fuller utilization of Dist. 2 refining capacity was removed last week with formal agreement by Defense Supplies Corp. to absorb excess cost of transporting crude by barge from Dist. 3 and by rail from Wyoming in Dist. 4, retroactive to April 10, 1944.

Action was in form of an amendment to Compensatory Adjustments Regulation No. 5, under which DSC has been compensating companies for tank car shipments of West Texas crude since Dec. 4, 1943. In addition to setting compensation schedules on barge and Wyoming rail shipments, the amendment also establishes basis on which DSC will compensate refiners on West Texas crude transported through Stanolind pipe line to Cushing, Okla., thence by rail to Dist. 2 refining points.

As a service to the industry Platt's Oilgram has printed the complete text of the new DSC compensatory schedule on excess cost for Dist. 2 refiners in transporting crude by barge from Dist. 3 and by rail from Wyoming in Dist. 4. Copies of the amendment may be obtained for $1.00 by writing to the W. C. Platt Co., 1213 W. Third St., Cleveland 13, Ohio.

Sinclair Co. Declared Innocent In $3,400,000 Royalty Suit

NPN News Bureau

TULSA—Judgment in favor of the Sinclair Refining Co. was filed May 1, by Federal Judge Royce H. Savage, in the government's $3,400,000 suit to recover royalty interests alleged due the Osage Indian tribe, and in findings of fact and conclusions of law filed at the same time the court found the defendant not guilty of fraud. Whether the government will appeal the decision is up to the U. S. solicitor general and probably will not be decided for some time.

Canol Project in Operation

Special to NPN

WHITEHORSE, YUKON TERRITORY—With much fanfare and absolutely no mention of the fact that the Truman senate committee had blasted the undertaking from start to finish, the Army's controversial Canol project was placed officially in operation on April 30.

First crude from the Norman wells field started on the run through the new refinery here on that date, almost two years after construction was started.

Refinery Operations

(American Petroleum Institute figures in thousands of barrels of 42 gal. each. Figures include reported totals plus estimate of unreported amounts and are therefore on a Bureau of Mines basis.)

Districts	Daily Potential Refining Capacity Week Ended Apr. 22	Daily Potential Refining Capacity Week Ended Apr. 15	Per Cent of Refining Capacity Reporting Week Ended Apr. 22	Per Cent of Refining Capacity Reporting Week Ended Apr. 15	Daily Average Crude Runs to Stills Week Ended Apr. 22	Daily Average Crude Runs to Stills Week Ended Apr. 15	Per Cent of Reporting Capacity Operated Week Ended Apr. 22	Per Cent of Reporting Capacity Operated Week Ended Apr. 15
Combined**	2,518	2,518	90.3	90.3	2,220	2,323	88.2	92.3
Appalachian (Dist. No. 1)	130	130	83.9	83.9	110	96	84.6	73.8
Appalachian (Dist. No. 2)	47	47	87.2	87.2	56	44	119.1	93.6
Ind., Ill., Ky.	824	824	85.2	85.2	743	734	90.2	89.1
Okla., Kans., Mo.	418	416	80.2	80.1	354	351	84.7	84.4
Rocky Mt. (Dist. No. 3)	8	8	26.9	26.9	11	11	137.5	137.5
Rocky Mt. (Dist. No. 4)	141	141	58.3	58.3	96	102	68.1	72.3
California	817	817	89.9	89.9	800	786	97.9	96.2
Total U. S.—B. of M. Basis	4,903	4,901	87.3	87.3	4,390	4,447	89.5	90.7
U. S.—B. of M. Basis April 24, 1943					3,743			

Districts	Gasoline Production at Refineries inc. Natural Blended Week Ended Apr. 22	Gasoline Production at Refineries inc. Natural Blended Week Ended Apr. 15	Stocks of Finished and Unfinished Gasoline Week Ended Apr. 22	Stocks of Finished and Unfinished Gasoline Week Ended Apr. 15	Total Stocks Gas Oil & Distillates Week Ended Apr. 22	Total Stocks Gas Oil & Distillates Week Ended Apr. 15	Total Stocks Residual Fuel Oil Week Ended Apr. 22	Total Stocks Residual Fuel Oil Week Ended Apr. 15
Combined**	6,761	6,879	38,697	38,796	14,928	14,796	15,439	16,269
Appalachian (Dist. No. 1)	333	289	2,265	2,344	803	723	220	245
Appalachian (Dist. No. 2)	145	146	1,389	1,111	92	343	116	100
Ind., Ill., Ky.	2,700	2,568	20,150	20,348	4,930	4,966	2,665	2,661
Okla., Kans., Mo.	1,169	1,299	8,429	8,449	1,469	1,449	1,198	1,221
Rocky Mt. (Dist. No. 3)	39	35	81	76	16	20	31	37
Rocky Mt. (Dist. No. 4)	274	309	2,216	2,117	346	356	540	519
California	2,012	2,259	15,502	15,537	7,911	7,908	30,852	30,191
Total U. S.—B. of M. Basis	13,433	13,784	*88,729	88,778	30,495	30,561	51,061	51,238
U. S.—B. of M. Basis April 24, 1943	10,453		90,751		30,838		67,494	

*Finished 76,743,000 bbls.; Unfinished 11,986,000 bbl.

**Includes East Coast, Inland Texas, Texas Gulf, Louisiana Gulf and North Louisiana-Arkansas districts.

U. S. Crude Oil Production

(American Petroleum Institute figures)

	WEEK ENDED April 22 Barrels (Daily Average)	WEEK ENDED April 15 Barrels (Daily Average)
Oklahoma	335,550	331,900
Kansas	263,800	272,300
Nebraska	1,200	1,200
Texas	1,910,350	1,910,350
Louisiana	358,650	358,550
Arkansas	79,550	79,600
Mississippi	42,850	40,850
Illinois	201,700	215,350
Indiana	13,850	14,000
Alabama	100	50
Florida	50	50
Eastern (Ill., Ind. & Ky. excluded)	72,500	72,250
Kentucky	24,350	22,100
Michigan	48,500	52,550
Wyoming	98,700	88,650
Montana	21,500	21,500
Colorado	8,200	8,500
New Mexico	112,050	112,900
California	833,900	829,500
Total, United States	4,427,350	4,432,150

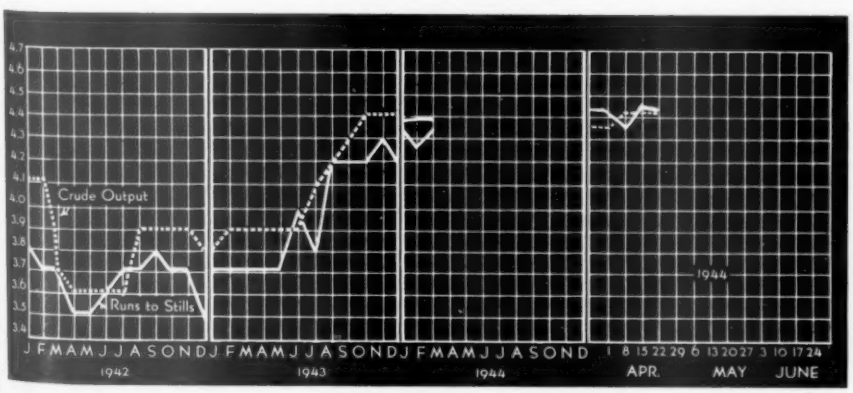
Crude Oil Stocks

(Bureau of Mines Figures in thousands of bbls.)

Grade or Origin	Apr. 22	Apr. 15	Change from Apr. 15
Penna. Grade	2,463	2,494	— 31
Other Appalachian	1,495	1,437	+ 58
Lima-Michigan	925	988	— 63
Illinois-Indiana	14,553	14,668	—115
Arkansas	2,868	2,834	+ 34
Kansas	8,348	8,278	+ 70
Louisiana	14,259	13,714	+545
Northern	3,651	3,680	— 29
Gulf Coast	10,608	10,034	+574
Mississippi	874	728	+146
New Mexico	7,259	7,290	— 31
Oklahoma	32,226	32,084	+142
Texas	113,512	114,625	—1,113
East Texas	22,279	22,793	—514
West Texas	31,541	31,211	—670
Gulf Texas	33,343	33,577	—234
Other Texas	27,349	27,044	+305
Panhandle	6,090	6,045	+ 45
North	5,994	5,956	+ 38
South	5,299	5,239	+ 60
Other	9,966	9,804	+162
Rocky Mountain	9,552	9,673	—121
California	23,974	24,193	—219
Foreign	1,324	1,182	+142
Total gasoline bearing in U. S.	233,632	234,188	—556
Heavy in California	6,295	6,286	+ 9

Crude Production & Runs to Stills

(Millions of Barrels)


Crude Output
Runs to Stills
1942
1943
1944
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D 1 8 15 22 29 6 13 20 27 3 10 17 24
APR.
MAY
JUNE

N.P.N. Gasoline Index

	Dealer T.W. Cents Per Gal.	Tank Car Cents Per Gal.
May 1	10.51	6.65
Month ago	10.51	6.65
Year ago	10.33	6.75

Dealer index is an average of "undivided" dealer prices, ex-tax, in 50 cities.

Tank car index is weighted average of following wholesale markets for regular-grade gasoline, FOB refineries or terminals: Okla., Mid-Western, W. Penna., Calif., N. Y. Harbor, Philadelphia, Jacksonville, Boston and Gulf Coast.

Pennsylvania Crude Runs

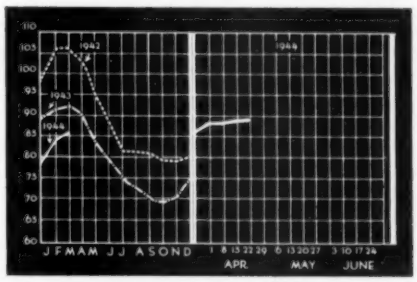
(Compiled by National Petroleum Assn. from reports of all companies refining Pennsylvania crude. Figures in bbls.)

DAILY AVERAGE

Week Ended April 22,1944	Week Ended April 15, 1944	Week Ended April 24,1943
74,685	69,736	76,625

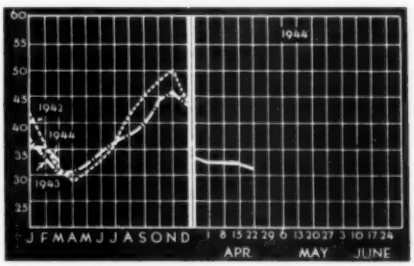
Gasoline Stocks

(Millions of Barrels)



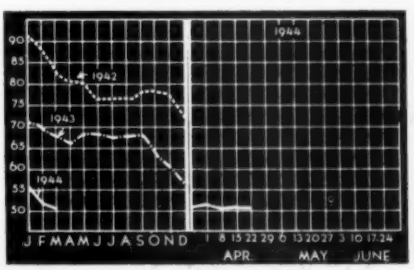
Gas Oil & Distillate Stocks

(Millions of Barrels)



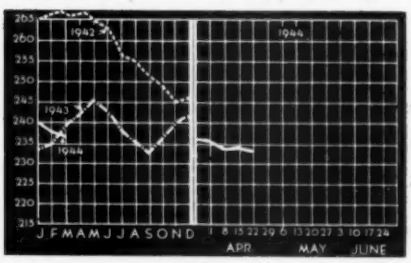
Residual Fuel Oil Stocks

(Millions of Barrels)



Crude Oil Stocks

(Millions of Barrels)



Taxable Gasoline Volume Up For 2-Month Penna. Period

Special to NPN

HARRISBURG—Taxes were collected on a total of 167,083,500 gallons of gasoline in Pennsylvania during the January-February period of this year, an increase of 26,237,695 gallons over the corresponding period of 1943, the state Department of Revenue announced.

U. S. government tax exempt gallonage, not included in aforementioned total, amounted to 3,903,617 for the first two months of this year, as compared to 3,381,131 for the same period last year, the report said.

Market Reports

MIDCONTINENT—In spite of temporary halt in gasoline demand this week due to floods, refiners have been unable to add to inventory. Texas refiners, not hit by heavy rains, report gasoline call increasing, causing them to run behind with orders. Kerosine termed "most scarce product", continues under heavy call. Burning oils demand has let up some, refiners say, but production of Navy Diesel fuel has cut output considerably. Except for tie-ups caused by high water, transportation was said to be in "pretty good shape". Demand for blended oils reported brisk, neutrals market continues weak and bright stock "firm at ceiling prices."

Six cars Grade 26-70 natural gasoline reported sold at 4.75c f.o.b. Group 3, and five cars reported sold at 4.375c f.o.b. Breckenridge.

° ° °

ATLANTIC COAST—Kerosine continues tight. Gasoline stocks likewise reported exceedingly low along seaboard, especially in Pittsburgh area. Many suppliers report working on day-to-day basis. Residuals steady with bunker "C" posted at $1.65-2.07 at New York harbor, prevailing price of 15.9 degree gravity is $1.77. Supplies of No. 2 fuel oil reported comfortable due to "stepped-up" deliveries of 20 in. products pipeline and cut in civilian demand as mild weather prevails.

° ° °

PENNSYLVANIA—All refined products tight throughout the week with inquiries heavy for bright stock. Summer trade and trucks which are getting older have increased demand for bright stock needed for blending to make the heavier oil for withstanding the higher summer temperatures. Cylinder stocks have been put into bright stocks to ease demand.

Fuel oils continued tight as PAW extended oil-to-gas conversion for industrial plants until June 1. Demand for Penna. neutrals very strong but prices remain firm as refiner quoting 28c for 200 vis. 25 p.t. reported low stocks and selling only on day-to-day basis. Crude shortage has caused scarcity in supplies of all refined products.

° ° °

MIDWEST — Requests for gasoline were piling up at the end of last week as clear weather sent farmers into fields. Attempts to get housebrand and third grade gasoline on inter-refinery purchase were meeting with little success since supplies of both grades gasoline are exceptionally tight. Refinery storages are expected to last for about one month and in many cases Michigan and Midwestern refiners already have only daily production of gasoline to fall back on, having had no opportunity to accumulate supplies. Farmers, however, generally have well filled storages, refiners report. Volume of straight run gasoline sales is rising rapidly in Michigan. One refiner declared it's now 6½ times greater than during March.

Little change in other product markets. Burning oils have shown little let-up in demand and supplies continue extremely short. Residuals moving out rapidly. Lubricating oil demand absorbing all available quantities of the product. No price changes from either refiners or marketers reported last week.

° ° °

CALIFORNIA—Markets continued in the stalemate which has existed for some weeks. In all products, it is a sellers market with supply being unable to meet demand.

Independents continue to quote a tank wagon delivered price about 1 cent under the majors. This is done, not because they could not get ceiling for their product, but more to help out their dealers.

° ° °

GULF COAST—Military demands are absorbing refined products at the Gulf "as fast as they are being made." Stock piles of lighter gravity residuals are building up, due to increased production of 100-octane. Demand for gasoline from eastern suppliers continues. Prices firm at current levels.

CRUDE PRICES

Complete tables of crude oil prices are carried in this week's issue of NPN on pages 61 and 62.

Southeastern Fields

Posted by Allied Pipe Line Corp.

Schedule M is for Tinsley field (May 22, 1943) and Pickens field (Sept. 28, 1943), both in Mississippi. Note: Carter Oil posts same Pickens prices, and Standard Oil of Louisiana (Mar. 8, 1944) posted same prices for Eucutta, Mississippi, crude beginning with Below 22 at $0.80 and ending with 30 and Above at $0.98.

Summary of Daily Gasoline Prices (April 24 to May 1)

	Monday May 1	Friday April 28	Thursday April 27	Wednesday April 26	Tuesday April 25
U. S. Motor (ASTM octane)					
76 octane Ethyl:					
Oklahoma	6.75	6.75	6.75	6.75	6.75
Mid-Western (Group 3 basis)	6.75 - 7.25	6.75 - 7.25	6.75 - 7.25	6.75 - 7.25	6.75 - 7.25
N. Tex. (For shpt. to Tex. & N. M. dest'ns.)	7	7	7	7	7
W. Tex. (For shpt. to Tex. & N. M. dest'ns.)	7 (2)	7 (2)	7 (2)	7 (2)	7 (2)
72 octane:					
Oklahoma	6	6	6	6	6
Mid-Western (Group 3 basis)	6	6	6	6	6
N. Tex. (For shpt. to Tex. & N. M. dest'ns.)	6	6	6	6	6
W. Tex. (For shpt. to Tex. & N. M. dest'ns.)	6	6	6	6	6
63-66 octane:					
Oklahoma	5.625 (2)	5.625 (2)	5.625 (2)	5.625 (2)	5.625 (2)
Mid-Western (Group 3 basis)	5.6 - 5.625	5.6 - 5.625	5.6 - 5.625	5.6 - 5.625	5.6 - 5.625
N. Tex. (For shpt. to Tex. & N. M. dest'ns.)	5.625 (1)	5.625 (1)	5.625 (1)	5.625 (1)	5.625 (1)
W. Tex. (For shpt. to Tex. & N. M. dest'ns.)	5.75 (1)	5.75 (1)	5.75 (1)	5.75 (1)	5.75 (1)
60 octane & below:					
Oklahoma	5.25	5.25	5.25	5.25	5.25
Mid-Western (Group 3 basis)	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25
N. Tex. (For shpt. to Tex. & N. M. dest'ns.)	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25	5.2 - 5.25
W. Tex. (For shpt. to Tex. & N. M. dest'ns.)	5.25	5.25	5.25	5.25	5.25
Motor Gasoline, 72 octane (ASTM)					
New York harbor	9.2 - 9.4	9.2 - 9.4	9.2 - 9.4	9.2 - 9.4	9.2 - 9.4
New York harbor, barges	9.1 - 9.3	9.1 - 9.3	9.1 - 9.3	9.1 - 9.3	9.1 - 9.3
Philadelphia district	9.2	9.2	9.2	9.2	9.2
Baltimore district	8.95	8.95	8.95	8.95	8.95
Motor Gasoline:					
Western Penna. Bradford-Warren:					
"Q" Gasoline, Min. 70 Oct. (ASTM)	7.75 - 8.95	7.75 - 8.95	7.75 - 8.95	7.75 - 8.95	7.75 - 8.95
Western Penna. Other Districts:					
"Q" Gasoline, Min. 70 Oct. (ASTM)	7.75 - 8.45	7.75 - 8.45	7.75 - 8.45	7.75 - 8.45	7.75 - 8.45

OIL PRICE SECTION

★

At Refineries and Terminals and by Tank Wagon

Prices herewith are reproduced from Platt's *OILGRAM* Daily Oil Price Service, associated with National Petroleum News, whose representatives in all NPN-OILGRAM offices devote their time exclusively to reporting oil industry prices everywhere.

Prices shown are actual sales prices, or quotations meaning sellers' general offers or posted prices; for current sales and shipment; for the business day or period stated; except Tank Wagon prices, prices are for bulk lots such as tank car and motor transport; barge or tanker cargo lot prices are identified; FOB refineries or terminals; in cents per gal. except where shown in bbls. of 42 gals.; ex all fees and taxes; for crude oil and its products lawfully produced and transported; reported as received by *OILGRAM* and National Petroleum News but not guaranteed; for subscribers' private use only and not for resale or distribution or publication. For further details of price conditions apply to any *NPN-OILGRAM* office or see back of any *OILGRAM* Price Service invoice.

For complete price service delivered daily from nearest *OILGRAM* publishing office, New York, Cleveland and Tulsa, Okla. address Platt's *OILGRAM*, 1213 W. 3rd St., Cleveland (13), Ohio. Annual subscription rate payable in advance $100 a year via train mail and $125 per year via air mail.

Refinery Prices

Gasoline —U. S. Motor (A S T M) except where otherwise specified

Prices in Effect	May 1	April 24
OKLAHOMA		
76 oct. Ethyl...	6.75	6.75
72 oct.....	6	6
63-66 oct.....	5.625(2)	5.625 (2)
60 oct. & below..	5.25	5.25
60-62, 400 e.p...	5.25 (1)	5.25 (1)
MID-WESTERN (Group 3 basis)		
76 oct. Ethyl...	6.75 – 7.25	6.75 – 7.25
72 oct.....	6	6
63-66 oct.....	5.6 – 5.625	5.6 – 5.625
60 oct. & below..	5.2 – 5.25	5.2 – 5.25
N. TEX. (For shpt. to Tex. & N. M. dest'ns.)		
76 oct. Ethyl...	7	7
72 oct.....	6	6
63-66 oct.....	5.625 (1)	5.625 (1)
60 oct. & below..	5.2 – 5.25	5.2 – 5.25
60-62, 400 e.p...	5.375 (1)	5.375 (1)
W. TEX. (For shpt. to Tex. & N. M. dest'ns.)		
76 oct. Ethyl...	7 (2)	7 (2)
72 oct.....	6	6
63-66 oct.....	5.75 (1)	5.75 (1)
60 oct. & below..	5.25	5.25
CENT. W. TEX. (Prices to truck transports)		
76 oct.....	7 (2)	7 (2)
72 oct.....	6 (2)	6 (2)
67-69 oct.....	....	....
62 oct & below..	5.25 (2)	5.25 (2)
AMARILLO, TEX. (For shpt. to W. Okla. & Tex. differential territory.)		
60 oct. & below..	No Price	No Price
60-62, 400 e.p...	No Price	No Price
KANSAS (For Kansas destinations only)		
76 oct. Ethyl...	7.25 – 7.5 (2)	7.25 – 7.5(2)
72 oct.....	6.25 – 6.3	6.25 – 6.3
63-66 oct.....	5.9 (2)	5.9 (2)
60 oct. & below.	5.5	5.5
ARK. (For shipment to Ark. & La.)		
76 oct. Ethyl...	7 (1)	7 (1)
72 oct., leaded..	6 (1)	6 (1)
70-72 oct. "	5.875 (1)	5.875 (1)
62 oct. "	....	....
60 oct. & below, leaded.....	5.25 (1)	5.25 (1)
WESTERN PENNA. (Motor gasoline)		
Bradford-Warren: "Q" Gasoline, Min. 70 Oct. (ASTM)	7.75 – 8.95	7.75 – 8.95
Other districts: "Q" Gasoline, Min. 70 Oct. (ASTM)	7.75 – 8.45	7.75 – 8.45
CENTRAL MICHIGAN (FOB Central Mich. refinery group basis for shpt. within Mich.; shpts. may originate at plants outside Central group.) U.S. Motor: (Oct. ASTM):		
72 oct.....	8 – 8.5	8 – 8.5
67-69 oct.....	....	....
Str. run gasoline, excluding Detroit shpt.....	6	6
OHIO (S. O. Ohio quotations for statewide delivery and subject to exceptions for local price disturbances).		
72 oct.....	8.375	8.375
CALIFORNIA U.S. Motor:		
76 oct. (Ethyl)....	7.5 – 8.75	7.5 – 8.75
70-72 oct. (regular)	6.5 – 7.75	6.5 – 7.75
65 oct. & below (3rd grade).....	6.5 – 6.75	6.5 – 6.75

Kerosine, & Gas Fuel Oils

Prices in Effect	May 1	April 24
OKLAHOMA		
41-43 grav. w.w...	4.375	4.375
42-44 grav. w.w...	4.5	4.5
Range Oil.....	4	4
No. 1 P.W.....	3.875	3.875
No. 1 straw.....	....	....
No. 2 straw.....	3.625	3.625
No. 3 fuel.....	3.5 (2)	3.5 (2)
U. G. I. Gas Oil...	....	....
No. 6 fuel.....	....	....
14-16 fuel.....	$0.97 (2)	$0.97 (2)
MID-WESTERN (Group 3 basis)		
41-43 grav. w.w...	4.375	4.375
42-44 grav. w.w...	4.5	4.5
Range Oil.....	4 – 4.1 (2)	4 – 4.1(2)
No. 1 p.w.....	3.875	3.875
No. 2 straw.....	3.625	3.625
No. 3.....	....	....
No. 5.....	....	....
No. 6.....	$0.80 (1)	$0.80 (1)
N. TEX. (For shpt. to Tex. & N. M. dest'ns.)		
41-43 grav. w.w....	4.375	4.375
42-44 grav. w.w....	4.5 (1)	4.5 (1)
No. 1 P.W.....	3.875 (1)	3.875 (1)
AMARILLO, TEX. (For shpt. to W. Okla. & Tex. differential territory.)		
42-44 grav. w.w...	4.5 (1)	4.5 (1)
No. 1 straw.....	No Price	No Price
KANSAS (For Kansas destinations only).		
41-43 grav. w.w...	No Price	No Price
42-44 grav. w.w...	4.7 – 4.75	4.7 – 4.75
No. 1 p.w.....	4.1	4.1
No. 6 fuel.....	$0.85	$0.85
ARK. (For shipment to Ark. and La.)		
41-43 grav. w.w...	....	....
42-44 w.w. kero...	4.5 (1)	4.5 (1)
No. 1.....	4 (1)	4 (1)
No. 2.....	3.625 (1)	3.625 (1)
No. 3 fuel.....	3.5 (1)	3.5 (1)
Tractor fuel, for shpt. to Ark. points only....	5.125 (1)	5.125 (1)
Diesel fuel 52 & below.....	4 (1)	4 (1)
Diesel fuel 58 & above.....	4.25 (1)	4.25 (1)
WESTERN PENNA.		
Bradford-Warren:		
45 grav. w.w.....	6.55 – 8.05	6.55 – 8.05
46 grav. w.w.....	6.675 (1)	6.675 (1)
No. 1 fuel.....	6.875– 8.05	6.875– 8.05
No. 2 "	6.75–7.625(2)	6.75–7.625 (2)
No. 3 "	6.75–7.75 (2)	6.75–7.75 (2)
36-40 gravity.....	6.625–6.75 (2)	6.625–6.75(2)
Other districts:		
45 grav. w.w.....	7.25 – 7.925	7.25 – 7.925
46 grav. w.w.....	7.25 – 7.625	7.25 – 7.625
47 grav. w.w.....	7.375– 7.875	7.375– 7.875
No. 1 fuel.....	6.875– 7.375	6.875– 7.375
No. 2 "	6.75 – 7.375	6.75 – 7.375
No. 3 "	6.75 – 7.375	6.75 – 7.375
36-40 grav. Pittsburgh dist. prices excluded.....	6.625– 7.375	6.625– 7.375
CENTRAL MICHIGAN (FOB Central Mich. refinery group basis for shpt. within Mich.; shpts. may originate at plants outside Central group.)		
47-49 gravity w.w.	5.8 – 6	5.8 – 6
P.W. Distillate...	5.5	5.5
No. 3 gas oil, Straw	5	5
U.G.I. gas oil....	4.5 (2)	4.5 (2)
Fuel Oils (*Vis. at* 100).		
300-500 Vis....	....	....
100-300 Vis....	4.5	4.5
OHIO (S. O. quotations for statewide delivery)		
Kerosine.....	7	7
CALIFORNIA		
40-43 grav. w.w...	5 – 7	5 – 7
San Joaquin Valley:		
Heavy fuel.....	$1.10 (2)	$1.10 (2)
Light fuel.....	$1.20 (2)	$1.20 (2)
Diesel fuel.....	4 (2)	4 (2)
Stove dist.....	5 (2)	5 (2)
Los Angeles:		
Heavy fuel.....	$1.10 (2)	$1.10 (2)
Light fuel.....	$1.20(2)	$1.20 (2)
Diesel fuel.....	4 (2)	4 (2)
Stove dist.....	5	5
San Francisco:		
Heavy fuel.....	$1.15 (1)	$1.15 (1)
Light fuel.....	$1.25 (1)	$1.25 (1)
Diesel fuel.....	4 (1)	4(1)
Stove dist.....	5 (1)	5(1)

NOTE: All above heavy fuels meet Pacific specification 400; light fuel, spec. 300; Diesel fuels, spec. 200; and stove distillate, spec. 100.

Lubricating Oils

Prices in Effect	May 1	April 24
WESTERN PENNA. Prices are for sales made, or offers reliably reported, to jobbers & compounders only. **Viscous Neutrals**—*No. 3 col. Vis. at* 70°*F.*		
200 Vis. (180 at 100°) 420-425 fl.		
0 p.t.....	35 (1)	35 (1)
10 p.t.....	34 (1)	34 (1)
15 p.t.....	33 (1)	33 (1)
25 p.t.....	28–33	28–33
150 Vis. (143 at 100°) 400-405 fl.		
0 p.t.....	33 (1)	33 (1)
10 p.t.....	32 (1)	32 (1)
15 p.t.....	31 (1)	31 (1)
25 p.t.....	26–31	26–31
Cylinder Stocks		
Brt. stk., 145-155 *vis. at* 210°, 540-550 fl., *No. 8 col.*		
10 p.t.....	30.5 (1)	30.5 (1)
15 p.t.....	29.5 (1)	29.5 (1)
25 p.t.....	25	25
600 S.R. filterable.	15	15
650 S.R.....	15.5	15.5
600 fl.....	16	16
630 fl.....	17	17
MID-CONTINENT (F. o. b. Tulsa)		
Neutral Oils (*Vis. at* 100° *F. 0 to* 10 *P.P.*)		
Pale Oils:		
Vis. Color		
60-85—No. 2....	7.5–8	8
86-110—No. 2...	7.5–8.5	8.5
150—No. 3.....	11 –14.5	14.5
180—No. 3.....	11.5–15	15
200—No. 3.....	12 –5	15
250—No. 3.....	14 –16.5	16–16.5
280—No. 3.....	15 –7	17
300—No. 3.....	16 –18	18
Red Oils:		
180—No. 5.....	15 (1)	15 (1)
200—No. 5.....	15 (1)	15 (1)
280—No. 5.....	No Price	No Price
300—No. 5.....	17.5 (2)	17.5 (2)

Note: Viscous Neutrals, 15-25 p.p. generally are quoted 0.5c under 0-10 p.p. oils. Non-viscous oils, 15-25 p.p.; generally are quoted 0.25c under 0-10 p.p. oils.

Bright Stock—*Vis. at* 210°		
200 Vis. D.....	27 (1)	27 (1)
150-160 Vis. D:		
0 to 10 p.p.....	23	23
10 to 25 p.p.....	22.5–23	22.5–23
25 to 40 p.p.....	23 (1)	23 (1)
150-160 Vis. E....	22 (1)	22 (1)
120 Vis. D:		
0 to 10 p.p.....	22 (2)	22 (2)
600 S.R. Dark Green.....	8.5 (1)	8.5 (1)
600 S.R. Olive Green.....	10–11 (2)	10–11 (2)
631 S.R.....	....	....
Black Oil.....	5.5 (1)	5.5 (1)

NOTE—Discounts of 0.5c to 1c off for contracts to "meet competition" are generally being allowed from these posted prices on "conventional" oils.

SOUTH TEXAS Neutral Oils		
Pale Oils (*Vis. at* 100°*F.*)		
Vis. Color		
100 No. 1½-2½.	6.5	6.5
200 No. 2-3.....	8.75	8.75
300 No. 2-3.....	9.25	9.25
500 No. 2½-3½.	10	10
750 No. 3-4.....	10.25	10.25
1200 No. 3-4.....	10.375	10.375
2000 No. 4.....	10.5	10.5

(Continued on next page)

NOTE—Parenthetical figures after prices indicate number of companies quoting when less than three companies are quoting.

NOTICE—Owing to great demand, refiners generally limit quotations to regular customers and refuse bids, though higher, from others. Refiners' prices and sales shown: bids reported in market leads.

Refinery Prices (Continued)

Prices in Effect	May 1	April 24
Red Oils:		
100 No. 5-6	6.5 (2)	6.5 (2)
200 No. 5-6	8.75	8.75
300 No. 5-6	9.25	9.25
500 No. 5-6	10	10
750 No. 5-6	10.25	10.25
1200 No. 5-6	10.375	10.375
2000 No. 5-6	10.5	10.5

CHICAGO (From Mid-Continent p.l. crude.)
Neutral oils *vis. at* 100° *F. to* 10 *p. p.*

Pale Oils		
Vis. Color		
60-85—No. 2	9.5 (1)	9.5 (1)
86-110—No. 2	10 (1)	10 (1)
150—No. 3	15.5 (1)	15.5 (1)
180—No. 3	16 (1)	16 (1)
200—No. 3	16 (1)	16 (1)
250—No. 3	17 (1)	17 (1)
Red Oils:		
180—No. 5	16 (1)	16 (1)
200—No. 5	16 (1)	16 (1)
250—No. 5	17 (1)	17 (1)
280—No. 5	18 (1)	18 (1)
300—No. 5	18.5 (1)	18.5 (1)

Note: Viscous oils, 15 to 30 p.p. are quoted 0.5c lower; 60-85 and 86-110 No. 2 non-viscous oils, 15 to 30 p.p., 0.25c lower.

Unfiltered Steam Refined: (*Viscosity at* 210°)

140	11.5 (1)	11.5 (1)
160	12.5 (1)	12.5 (1)
200	13.5 (1)	13.5 (1)

Bright stocks, 160 *vis. at* 210 *No.* 8 *color:*

0 to 10 p.p.	24 (1)	24 (1)
15 to 25 p.p.	23.5 (1)	23.5 (1)
30 to 40 p.p.	21.5 (1)	21.5 (1)
E filtered Cyl. Stock	15.5 (1)	15.5 (1)

Note: To obtain prices delivered in Chicago, add 0.25c per gal.

Natural Gasoline

(Group 3 & Breckenridge prices are to blenders on freight basis shown below. Shipments may originate in any Mid-Continent manufacturing district.)

FOB GROUP 3

Grade 26-70	4.75 (Quote)	4.75 (Sales)

FOB BRECKENRIDGE

Grade 26-70	4.375 (Quote)	4.375 (Quote)

CALIFORNIA (FOB plants in Los Angeles basin)

21 pound vapor pressure for blending	4.75 - 5.375	4.75 - 5.375

Naphtha and Solvent

(*FOB Group* 3)

Stoddard solvent	6.625	6.625
Cleaners' naphtha	7.125	7.125
V.M.&P. naphtha	7.1 - 7.125	7.1 - 7.125
Mineral spirits	6.1 - 6.125	6.1 - 6.125
Rubber solvent	7.1 - 7.125	7.1 - 7.125
Lacquer diluent	7.375- 8.125	7.375- 8.125
Benzol Diluent	7.875- 8.625	7.875- 8.625

WESTERN PENNA.

Bradford-Warren District:		
Stoddard Solvent	7.5 (1)	7.5 (1)
Other Districts:		
Untreated naphtha	7 - 7.25	7 - 7.25
Stoddard solvent	7.25 - 8	7.25 - 8

OHIO (S. O. quotations for statewide delivery): V.M.&P. naphtha, D.C. naphtha, Varnolene &

Sohio solvent	10	10
Rubber solvent	9	9

Wax

WESTERN PENNA. (Bbls. C.L.)

White Crude Scale:		
122-124 A.m.p.	4.25 (2)	4.25 (2)
124-126 A.m.p.	4.25	4.25

OKLAHOMA (C.L. FOB Refinery)

Semi-refined:		
128 AMP min., white, 50 kilo bags	No Price	No Price
132-134 AMP, bbls.	5.25 (1)	5.25 (1)

CHICAGO (FOB Chicago district refinery of one refiner, in bags, carloads. Carloads, slabs loose 0.4c less. Melting points are EMP (ASTM) methods; add 3° to convert into AMP.)

Fully refined:		
122-124 (bags only)	5.6	5.6
125-127	6	6
127-129	6.25	6.25
130-132	6.55	6.55
132-134	6.8	6.8
135-137	7.55	7.55

Petrolatums

WESTERN PENNA. (Bbls., carloads; tank cars 0.5c per lb. less.)

Snow White	6.125- 7.25	6.125- 7.25
Lily White	5.375- 6.25	5.375- 6.25
Cream White	4.375- 5.5	4.375- 5.5
Light Amber	3.375- 4	3.375- 4
Amber	3.125- 3.75	3.125- 3.75
Red	3 - 3.5	3 - 3.5

Tank Wagon Prices

Commercial or consumer tank car, tank wagon, dealer, and service station prices for gasoline **do not include taxes;** *they do, however, include inspection fees as shown in general footnote. Gasoline taxes, shown in separate column, include 1.5c federal, and state taxes; also city and county taxes as indicated in footnotes. Kerosine tank wagon prices also do not include taxes; kerosine taxes where levied are indicated in footnotes. Dealer discounts are shown in footnotes. These prices in effect May 1, 1944 as posted by principal marketing companies at their headquarters offices, but subject to later correction.*

S. O. N. J.

Esso (*Regular Grade*)	Consumer Tank Wagon	Dealer T.W.	Gasoline Taxes	Kerosine T.W.
*Atlantic City, N. J.	10.2	10.7	4.5	10
*Newark, N. J.	10.2	10.7	4.5	10
Annapolis, Md.	10.55	11.05	5.5	...
Baltimore, Md.	9.95	10.45	5.5	10.8
Cumberland, Md.	11.35	11.85	5.5	12.3
Washington, D. C.	10.2	10.7	4.5	11.3
Danville, Va.	11.65	12.15	6.5	12.55
Norfolk, Va.	10.45	10.95	6.5	12.3
Petersburg, Va.	10.75	11.25	6.5	13.3
Richmond, Va.	10.75	11.25	6.5	13.3
Roanoke, Va.	11.95	12.45	6.5	12.8
Charleston, W. Va.	12.25	12.75	6.5	13.6
Parkersburg, W. Va.	11.55	12.05	6.5	13.3
Wheeling, W. Va.	11.55	12.05	6.5	13.9
Charlotte, N. C.	12.1	12.6	7.5	11.6
Hickory, N. C.	12.65	13.15	7.5	12.6
Mt. Airy, N. C.	12.5	13.0	7.5	11.8
Raleigh, N. C.	11.85	12.35	7.5	12.6
Salisbury, N. C.	12.15	12.65	7.5	13.0
Charleston, S. C.	10.95	11.45	7.5	....
Columbia, S. C.	11.8	12.3	7.5	....
Spartanburg, S. C.	12.5	13.0	7.5	....

	Mineral Spirits T.W.	V.M.&P. T.W.
Newark, N. J.	13	14.5
Baltimore, Md.	15.5	....
Washington, D. C.	15.5	....

Fuel Oils—T.W.	No. 1	No. 2	No. 3
Atlantic City, N. J.	10	9	9
Newark	10	9	9
Annapolis, Md.	...	...	...
Baltimore	9.8	9	9
Washington, D. C.	10.3	9.4	9.4
Norfolk, Va.	10	8.8	8.8
Petersburg	10.3	9	...
Richmond	10.3	9	9
Charlotte, N. C.	10.6	10.4	...
Hickory, N. C.	....	10	...
Raleigh	11.6	10.1	...
Charleston, S. C.	....	9	...
Columbia	....	10	...
Spartanburg	....	10.8	...

*Effective Aug. 5, '42 minimum retail resale price of 14.2c posted thru New Jersey.

Discounts:

Esso gasoline—to undivided dealers, 0.5c off dealer t.w.

Kerosine—1c off t.w. price for 25 gals. or more, under contract thru territory (Baltimore city contract not necessary) except no discount in state of New Jersey.

Naphthas—To buyers taking following quantities at one time: Newark, 2c per gal. on 200 gals. or more, less than 200 gals. 0.5c higher price; Baltimore, 2c off on 25 to 100 gals. and 3c on over 100 gals.; Washington, 2c off to contract buyers.

▸ (N.B. Prices are Continental's "structural" prices. Prices do not reflect temporary reductions made to meet local competition.)

Notice

These prices include inspection fees on both gasoline and kerosine, unless otherwise specified per gallon as follows:

Ala. 1/40c on gasoline, 1/2c on kerosine; Ark. 1/20c; Fl. 1/8c; Ill. 3/100c; Ind. 1/5c in lots of 25 bbls. or less, 2/25c in lots of more than 25 bbls.; Kans. 1/50c; La. 1/32c; Minn. 7/200c; Mis. 1/50c; Neb. 3/100c; Nev. gasoline 1/20c; N. C. 1/4c; N. Da. 1/20c; Okla. 2/25c; S. Car. 1/8c; S. Da. 1/20c; Tenn. 2/5c; and Wisc. 3/100c.

Kerosine inspection fees only: Iowa 3/50c; Mich. 1/5c per gal.

CONT'L OIL

	Conoco Bronz-z-z (*Reg*) †Tank Wagon	Demand (*3rd Grade*)	Gasoline Taxes	Kerosine T.W.
Denver, Col.	11	10	5.5	11
Grand Junc., Col.	12.5	11.5	5.5	12.5
Pueblo, Col.	10.5	9.5	5.5	10.5
Casper, Wyo.	11.5	10.5	5.5	12
Cheyenne, Wyo.	11	10	5.5	11.5
Billings, Mont.	12.5	11.5	6.5	12.5
Butte, Mont.	13.5	12.5	6.5	13.5
Great Falls, Mont.	12.5	11.5	6.5	12.5
Helena, Mont.	13	12	6.5	13
Salt Lake City, Utah	13.5	12.5	5.5	14.5
Boise, Ida.	14.1	13.1	6.5	16.5
Twin Falls, Ida.	15.6	14.6	6.5	17
Albuquerque, N. M.	10	9	*7	9.5
Roswell, N. M.	9.5	8.5	*7	9
Santa Fe, N. M.	10.5	9.5	*7.5	10
Ft. Smith, Ark.	9.5	9.25	*7	9.5
Texarkana, Ark.	9	8	*5.5	9
Muskogee, Okla.	9.5	8.5	7	8.5
Oklahoma City, Okla.	9.5	8.5	7	8.5
Tulsa, Okla.	9.5	8.5	7	8.5

*Taxes: In gasoline tax column are included these city taxes—Albuquerque, & Roswell, 0.5c, Santa Fe, 1c. Texas 4c state tax applies within city limits of Texarkana, Ark.; Okla. 5.5c state applies within city limits of Ft. Smith, Ark.

†To consumers & Dealers.

S. O. NEB.

(*Regular Grade*)	T.W. Dealer	Gasoline Taxes	Kerosine T.W.
Omaha	11.4	9.6	6.5	10.1
McCook	12.0	10.1	6.5	10.5
Norfolk	11.9	10.4	6.5	10.6
North Platte	12.2	10.6	6.5	11
Scottabluff	12.9	10.2	6.5	10.5

S. O. CAL.

	Standard Gasoline (*Regular Grade*) Posted Net Tank Truck	Posted Retail	Flight Gasoline (*Third Grade*) Posted Net Tank Truck	Posted Retail	Gasoline Taxes
San Francisco, Cal.	10	14	9	12	4.5
Los Angeles, Cal.	9.5	13.5	8.5	11.5	4.5
Fresno, Cal.	11	15	10	13	4.5
Phoenix, Ariz.	12	16	10	13	6.5
Reno, Nev.	12	16	11	14	5.5
Portland, Ore.	10.5	14.5	9.5	12.5	6.5
Seattle, Wash.	10.5	14.5	9.5	12.5	6.5
Spokane, Wash.	12.5	16.5	11.5	14.5	6.5
Tacoma, Wash.	10.5	14.5	9.5	12.5	6.5

Std. Aviation 73	Posted Net Tank Truck	Gasoline Taxes	Kerosine Tank Truck
San Francisco, Cal.	12.5	4.5	11.5
Los Angeles, Cal.	12	4.5	10
Fresno, Cal.	13.5	4.5	12.5
Phoenix, Ariz.	14.5	6.5	12.5
Reno, Nev.	14.5	5.5	13.5
Portland, Ore.	13	6.5	13.8
Seattle, Wash.	13	6.5	13.8
Spokane, Wash.	16	6.5	16.8
Tacoma, Wash.	13	6.5	13.8

Resale & Commercial: T.C. deliveries 0.25c per gal. off posted net tank truck.

Commercial: Retail deliveries, and/or tank truck deliveries of less than 40 gals., 4c per gal. above posted net tank truck price for Standard Aviation and Standard Gasoline, and 3c per gal. above posted net tank truck for Flight Gasoline, except single deliveries of less than 40 gals. to Marine trade only, which are billed at posted net tank truck price.

TEXAS CO.

	Gasoline—Dealer T.W. Fire-Chief (*Regular*)	Indian (*3rd Grade*)	Gasoline Taxes
Dallas, Tex.	7.5	6.5	5.5
Ft. Worth, Tex.	7.5	6.5	5.5
Wichita Falls, Tex	8.5	7.5	5.5
Amarillo, Tex.	8.5	7.5	5.5
Tyler, Tex.	8.5	7.5	5.5
El Paso, Tex.	11	10.5	5.5
San Angelo, Tex.	8.5	7.5	5.5
Waco, Tex.	8.5*	7*	5.5
Austin, Tex.	8.5	7.5	5.5
Houston, Tex.	8.5	7.5	5.5
San Antonio, Tex.	8.5	7.5	5.5
Port Arthur, Tex.	8.5	7.5	5.5

*Less 1c temporary allowance to all dealers.

(Continued on next page)

Tank Wagon Prices—Continued

S. O. IND.

Red Crown (*Regular Grade*)
Blue Crown (*Third Grade*)

	Red Dealer Prices Crown Cons. T.W.	Red Crown	Blue Crown	Gasoline Taxes	Kerosine T.W.
Chicago, Ill.	11.6	9.6	9.1	4.5	10.6
Decatur, Ill.	11.6	9.6	8.7	4.5	10.3
Joliet, Ill.	11.9	10.3	9.2	4.5	10.6
Peoria, Ill.	11.7	9.9	9.7	4.5	10.4
Indianapolis, Ind.	11.6	10.1	9.6	5.5	10.1
Evansville, Ind.	11.4	9.9	8.6	5.5	9.9
South Bend, Ind.	12	10.5	10	5.5	10.5
Detroit, Mich.	11.4	9.9	9.4	4.5	10
Grand Rapids, Mich.	11.4	9.9	9.4	4.5	9.9
Saginaw, Mich.	11.4	9.9	9.4	4.5	9.9
Green Bay, Wis.	12.2	10.7	10.2	5.5	10.9
Milwaukee, Wis.	12.1	10.6	10.1	5.5	10.8
La Crosse, Wis.	11.9	10.4	9.9	5.5	10.6
Minneapolis - St. Paul	11.9	10.4	9.9	5.5	10.6
Duluth, Minn.	12.2	10.7	10.2	5.5	10.9
Mankato, Minn.	11.9	10.4	9.9	5.5	10.6
Des Moines, Ia.	11.4	9.9	9.4	4.5	*10.1
Mason City, Ia.	11.7	10.2	9.7	4.5	*10.4
St. Louis, Mo.	11.0	9.5	9.3	*4.5	10.1
Kansas City, Mo.	11.0	9.5	8.6	*4.5	9.7
St. Joseph, Mo.	11.2	9.7	9.2	*4.5	9.9
Fargo, N. D.	12.9	11.4	10.9	5.5	11.6
Huron, S. D.	12.3	10.8	10.3	5.5	11
Wichita, Kans.	10.3	8.8	7.2	4.5	9.0

Stanavo Aviation 73 Octane
Withdrawn Jan. 1, 1944.

	Oleum Spirits	V.M.&P. Naphtha	Stanisol	*Taxes
(Prices are base prices before discounts)				
Chicago	13.5	13.8	12.8	4.5
Detroit	15.8	15	16.3	4.5
K. C., Mo.	13.3	14.3	13.8	1.5
St. Louis, Mo.	13.7	14.7	13.2	1.5
Milwaukee	14.4	15.4	14.9	5.5
Minneap'ls	14.2	15.2	13.5	5.5

Fuel Oils T.W.
Chicago

	Standard Heater Oil
1-99 gals.	9.3
100-149 gals.	8.3
150-399 gals.	7.8

	Stanolex Furnace Oil
1-99 gals.	8.8
100-149 gals.	7.8
150-399 gals.	7.8
400 gals. & over	7.3

	Stanolex Fuel A
1-749 gals.	6.5
750 gals. & over	5.75

	Stanolex Fuel C
1-749 gals.	6.0
750 gals. & over	5.25

Other Points Indianapolis	Stanolex Furnace Oil
1-99 gals.	9.0
100 gals. & over	8.0
Detroit	
1-99 gals.	8.7
100 gals. & over	7.7
Milwaukee	
1-99 gals.	9.0
100 gals. & over	8.0
Minneapolis	
1-99 gals.	9.1
100 gals. & over	8.1
St. Louis	
1-99 gals.	8.4
100 gals. & over	7.4
Kansas City	
1-99 gals.	8.1
100 gals. & over	7.1

*Taxes: In gasoline tax column are included these city taxes—Kansas City, St. Joseph and St. Louis, 1c. Iowa kerosine prices are ex 3c state tax. In naphtha tax column are included 1.5c federal tax and state taxes.

State sales, occupation, consumer and use taxes to be added when applicable.

HUMBLE OIL

Humble Motor Fuel (*Regular Grade*)

	Thriftane (*Third Grade*) *Tank Wagon	Humble Retail	Thriftane *Tank Wagon	Gasoline Retail	Taxes
Dallas, Tex.	7.5	10.5	6.5	10.5	5.5
Ft. Worth, Tex	6.5	9.5	6	7.5	5.5
Houston, Tex.	8.5	12.5	7.5	10.5	5.5
San Ant., Tex.	8.5	12.5	7.5	10.5	5.5

	Kerosine *Tank Wagon	Retail
Dallas, Tex.	7	10
Ft. Worth, Tex.	7	11
Houston, Tex.	8	11
San Antonio, Tex.	7	10

73 Oct. Aviation Gasoline	Tank Car
FOB Baytown, Tex.	8.5

*To all classes of dealers & consumers.

Fuel oils—Statewide prices are for t.w. & drum deliveries of 50 gals. or more; prices for deliveries of less than 50 gals. are 0.5c higher. Cleveland Division assumed the state-wide fuel oil tank wagon prices on Nos. 1, 2 and 3 fuel oil, effective May 10. However the price of 7.55c per gallon and No. 4 fuel oil (full compartment hose dumps only) will remain as heretofore, in Cleveland Division.

Naphthas—to contract consumers off t.w. prices—Statewide: 300 to 999 gals., 0.5c; 1000 to 2499 gals., 0.75c; 2500 to 4999 gals., 1c; 5000 or more gals., 1.5c. Lucas County: Less than 50 gals., tank wagon price, 50 to 249 gals., 0.5c; 250 to 499 gals., 1c; 500 gals. or over, 1.5c.

S. O. OHIO

*Sohio X-70 Gasoline (*Regular Grade*)

	Consumer T.W.	**Reseller	‡S.S. Gasoline Taxes	†Kerosine T.W.
Ohio, Statewide	12	10	13.5	5.5	9.3
Akron	12	9.5	12.5	5.5	9.3
Cincinnati	12	9.5	12.5	5.5	9.3
Cleveland	12	9.5	12.5	5.5	9.3
Columbus	12	9.5	12.5	5.5	9.3
Dayton	12	9.5	12.5	5.5	9.3
Marietta	12	9.5	12.5	5.5	9.3
Portsmouth	12	9.5	12.5	5.5	9.3
Toledo	12	9.5	12.5	5.5	9.3
Youngstown	12	9.5	12.5	5.5	9.3

Aviation Gasoline—Statewide

	Consumer Gasoline T.W.	Taxes
Sohio Aviation Gasoline clear Spec. AN-F-22	14.5	5.5
Esso Ethyl Aviation 73 Oct.	15.5	5.5
Esso Ethyl Aviation 80 Oct.	16.5	5.5
Esso Ethyl Aviation 87 Oct.	17.5	5.5
Esso Ethyl Aviation 91 Oct.	17.5	5.5
Esso Ethyl Aviation 100 Oct.	26.5	5.5

	†Naphtha—T.W. Statewide	Lucas County
S. R. Solvent	13.5	13.5
D. C. Naphtha	14.5	14.25
V.M.&P. Naphtha	14.5	14.25
Varnolene	14.5	14.25
Sohio Solvent	14.5	14.25

Fuel Oils—T.W.	No. 1	No. 2	No. 3	No. 4
Ohio, Statewide	8.3	8.3	7.8	*7.55

*Renown (third-grade) prices are same as X-70 unless otherwise noted.

**Except authorized agents.

†Kerosine prices are ex 1c state tax Naphtha prices are ex 1.5c federal & 4c state tax.

‡Prices at company-operated stations.

††Statewide prices are subject to exceptions other than those shown.

Discounts:

Esso aviation—on contract to hangar operators and resellers, 2c off consumer t.w.

*For Cleveland area only.

Canada

PRICES OF IMPERIAL OIL, LTD.

Per Imperial Gallon, which is 1.2 U. S. Gallons

IMPERIAL OIL

3-Star Imperial Gasoline (*Regular Grade*)

	†Gasoline T.W.	*Gasoline Taxes	†Kerosine T.W.
Hamilton, Ont.	17.5	11	18
Toronto, Ont.	17.5	11	18
Brandon, Man.	21	10	23
Winnipeg, Man.	20.5	10	22.5
Regina, Sask.	18	10	20
Saskatoon, Sask.	20.8	10	22.8
Edmonton, Alta.	18.9	10	20.9
Calgary, Alta.	16	10	18
Vancouver, B. C.	15	10	24
Montreal, Que.	17	11	17.5
St. John, N. B.	16.5	13	19
Halifax, N. S.	16.5	13	19

*Includes 3c Federal, and Provincial taxes. To divided & undivided dealers.
Absorption Gasoline—No. 26 R.V.P.—$2.28.

ATLANTIC REFINING

Atlantic White Flash (*Regular Grade*)

	Commercial T.W.	Dealer T.W.	Gasoline Taxes	Kerosine T.W.
Philadelphia, Pa.	10.2	10.7	5.5	12.25
Pittsburgh	10.7	11.2	5.5	12.6
Allentown	10.7	11.2	5.5	12.6
Erie	10.7	11.2	5.5	12.6
Scranton	10.7	11.2	5.5	12.6
Altoona	10.7	11.2	5.5	12.6
Emporium	10.7	11.2	5.5	12.6
Indiana	10.7	11.2	5.5	12.6
Uniontown	10.7	11.2	5.5	12.6
Harrisburg	10.7	11.2	5.5	12.6
Williamsport	10.7	11.2	5.5	12.6
Dover, Del.	....	11.2	5.5	12.6
Wilmington, Del.	....	10.7	5.5	12.1
Boston, Mass.	....	10.9	5.5	....
Springfield, Mass.	....	11.8	4.5	....
Worcester, Mass.	....	11.5	4.5	....
Fall River, Mass.	....	11	4.5	....
Hartford, Conn.	....	11.6	4.5	....
New Haven, Conn.	....	11	4.5	....
Providence, R. I.	....	11	4.5	....
Atlantic City, N. J.	....	10.7	4.5	10
Camden, N. J.	....	10.7	4.5	10
Trenton, N. J.	....	10.7	4.5	10
Annapolis, Md.	....	11.05	5.5	10.8
Baltimore, Md.	....	10.45	5.5	9.8
Hagerstown, Md.	....	11.55	5.5	10.3
Richmond, Va.	....	11.25	6.5	12.3
Wilmington, N. C.	....	11.55	7.5	11.9
Brunswick, Ga.	....	10.4	7.5	11.1
Jacksonville, Fla.	....	10.4	8.5	12.1

	Mineral Spirits T.W.†	V.M.&P. T.W.†
Philadelphia, Pa.	11	12.5
Lancaster, Pa.	12	13.5
Pittsburgh, Pa.	12.5	13.5

Fuel Oils—T.W.

	1	2	3	5	6*
Phila., Pa.	10.1	9	9	5.76	5.04*
Allentown, Pa.	10.6	9.3	9.3	....	....
Wilmington, Del.	10.1	9	9	....	....
Springfield, Mass.	10.2	9.4	9.4	....	....
Worcester, Mass.	10.2	9.3	9.3	....	....
Hartford, Conn.	10.5	9	9	....	....

‡Does not include 1c Georgia kerosine tax.

†Mineral Spirits prices also apply to Stoddard Solvent; V.M.&P. prices also apply to Light Cleaners Naphtha.
Discounts:

Gasoline—to undivided dealers, 0.5c off dealer t.w. except Georgia & Florida dealer t.w. and undivided dealer t.w. prices are same.

Kerosine—Thru Penna. & Delaware, 2c off t.w. price on t.w. deliveries of 25 gals. or more at one time.

*Residual fuel 13.0-15.9 gravity effective 10/17/43.

S. O. KY.

Crown Gasoline (*Regular*)
Standard (*Third Grade*)

	†Net Crown	Dealer Standard	Gasoline Taxes	Kerosine T.W.
Covington, Ky.	9.5	...	6.5	9.3
Lexington, Ky.	10.5	...	6.5	9.3
Louisville, Ky.	10	...	6.5	8.8
Paducah, Ky.	10	...	6.5	8.8
Jackson, Miss.	10	...	7.5	*9
Vicksburg, Miss.	9.5	...	7.5	*8.5
Birmingham, Ala.	10	...	*8.5	9
Mobile, Ala.	9	...	*9.5	9.5
Montgomery, Ala.	10	...	*9.5	10
Atlanta, Ga.	11.4	...	7.5	*12.1
Augusta, Ga.	11.4	...	7.5	*11.6
Macon, Ga.	11.4	...	7.5	12.1
Savannah, Ga.	10.4	...	7.5	11.1
Jacksonville, Fla.	10.4	...	8.5	10.1
Miami, Fla.	10.4	...	8.5	10.1
Pensacola, Fla.	9	8	*9.5	8
Tampa, Fla.	10.4	...	8.5	10.1

*Taxes: In tax column are included these city and county gasoline taxes: Mobile, 2c city; Birmingham, 1c city; Montgomery, 1c city and 1c county; Pensacola, 1c city. Georgia and Montgomery, Ala. have 1c kerosine tax, Mississippi 0.5c, not included in above prices.

†Consumer t.w. prices are same as net dealer prices.

S. O. LA.

Esso Gasoline (*Regular Grade*)

	Consumer Tank Wagon	Dealer T.W.	Gasoline Taxes	Kerosine T.W.
New Orleans, La.	8.75	9.25	8.5	*9
Baton Rouge, La.	8.75	9.25	8.5	*9.5
Alexandria, La.	8.75	9.25	8.5	*9.5
Lafayette, La.	9	9.5	8.5	*9
Lake Charles, La.	9	9.5	8.5	*11
Shreveport, La.	8.5	9	8.5	*8
Knoxville, Tenn.	10.5	11	8.5	12.5
Memphis, Tenn.	8.90	9.40	8.5	10.5
Chattanooga, Tenn.	10.5	11	8.5	11
Nashville, Tenn.	10.5	11	8.5	10
Bristol, Tenn.	10.95	11.45	8.5	13.1
Little Rock, Ark.	9.5	10	8	10

*Louisiana kerosine prices are ex 1c state tax
Discounts:

Esso Gasoline—To undivided dealers, 0.5c off dealer t.w.

(Continued on next page)

Seaboard Export Coastwise Prices

Atlantic Coast

(Prices are of refiners, FOB their refineries & their tanker terminals, & of tanker terminal operators FOB their terminals)—Prices in Effect May 1.

MOTOR GASOLINE

District	72 Oct. (ASTM)	68-70 Oct. (ASTM)	KEROSINE and/or NO. 1 FUEL
N. Y. Harb.	9.2 – 9.4	9.2 (1)	7.1
N. Y. Harb., barges	9.1 – 9.3	9.1 (1)	7
Albany	9.3 – 9.5	....	7.3
Philadelphia	9.2	....	7.2
Baltimore	8.95	8.85 (1)	7.2
Norfolk	8.7 – 8.95	8.5 (1)	7.1
Wilmington, N. C.	8.7 – 8.75	8.5 (1)	7.05
Charleston	8.7 – 8.8	8.1 (1)	7.2
Savannah	8.25 – 8.4	....	7.05
Jacksonville	8.27 – 8.4	....	7.05 (1)
Miami	8.27 (1)	....	7.05 (2)
Tampa	8.27 – 8.4	8.275 (1)	7.05
Pensacola	7 – 7.2 (1)	....	4.8 (1)
Mobile	7 – 7.2	....	4.75 (2)
New Orleans	6.125– 6.75	....	4.25 – 4.75
Portland	9.5 – 9.65	....	7.3
Boston	9.4 – 9.7	9.7 (1)	7.2
Providence	9.4 – 9.7	....	7.2

FUEL OILS

District	No. 2	No. 3	No. 5	No. 6
N. Y. Harb.	6.7	6.7	$1.95–$2.01 (a)	$1.65 –$2.07
N. Y. Harb., barges	6.6	6.6	....	....
Albany	6.8	6.8 (2)	....	$1.85–$2.27 (1)
Philadelphia	6.7	6.7	$1.98	$1.65 –$2.07
Baltimore	6.7	6.7	....	$1.65 –$2.07
Norfolk	6.7	6.7 (1)	....	$1.65–$2.07 (2)
Charleston	6.7	....	....	....
Savannah	6.7 (2)	....	....	$1.60–$2.02 (2)
Jacksonville	....	....	....	$1.60–$2.02 (1)
Miami	6.25	....	....	$1.60–$2.02 (1)
Tampa	....	....	....	....
Pensacola	6.25 (2)	....	....	$1.50–$1.92 (2)
Mobile	....	....	....	....
New Orleans	....	....	....	....
Portland	3.75 (2)	....	$1.27 (1)	$0.85–$1.27 (2)
Boston	6.8	6.8 (2)	....	$1.65–$2.07 (1)
Providence	6.7	6.7 (2)	$1.95–$2.07 (1)	$1.65 –$2.07
	6.7	6.7 (2)	$1.90 (1)	$1.65 –$2.07

(a) This price is for straight-run low pour test No. 5 fuel.

Pacific Export

In Ship's Bunkers, or deep tank lots:

Prices in Effect	May 1	April 24
Diesel Fuel, Pac. Spec. 200	$1.45	$1.45
Grade C fuel, Pac. Spec. 400	$1.10	$1.10

Tank Wagon Prices (Continued)

SOCONY VACUUM

	Socony Mobilgas (*Regular Grade*) Com. Cons. T.W.	Indiv. Dlr. T.W.	Gasoline Taxes
New York City			
Manhattan & Bronx	10.1	10.6	*5.5
Kings & Queens	10.1	10.6	*5.5
Richmond	9.7	10.2	*5.5
Albany, N. Y.	9.9	10.4	5.5
Binghamton, N. Y.	11	11.5	5.5
Buffalo	10.2	10.7	5.5
Jamestown, N. Y.	10.4	10.9	5.5
Mt. Vernon, N. Y.	10.1	10.6	5.5
Plattsburg, N. Y.	11	11.5	5.5
Rochester, N. Y.	10.8	11.3	5.5
Syracuse, N. Y.	10.5	11	4.5
Bridgeport, Conn.	10	10.5	4.5
Danbury, Conn.	10.5	11	4.5
Hartford, Conn.	10.6	11.1	4.5
New Haven, Conn.	10	10.5	4.5
Bangor, Me.	10.7	11.2	5.5
Portland, Me.	10.3	10.8	5.5
Boston, Mass.	9.9	10.4	4.5
Concord, N. H.	11.4	11.9	5.5
Lancaster, N. H.	12	12.5	5.5
Manchester, N. H.	11.3	11.8	5.5
Providence, R. I.	10	10.5	4.5
Burlington, Vt.	10.9	11.4	5.5
Rutland, Vt.	11	11.5	5.5

	Mineral Spirits T.W.	V.M.&P. T.W.
Buffalo; N. Y.	12.4	13.6
New York City	11	12
Rochester, N. Y.	13.2	14.4
Syracuse, N. Y.	14	....
Boston, Mass.	12	13
Bridgeport, Conn.	†16.3	†17.3
Hartford, Conn.	†16.3	†17.3
Providence, R. I.	13	14

	Kerosine Yard	Kerosine T.W.	Mobilfuel Diesel T.C.	Mobilfuel Diesel T.W.	Mobilheat Fuel Yard	Mobilheat Fuel T.W.
New York:						
Manhat'n & Bronx	7.5	10.3	...	9.3	7.1	9
Kings & Queens	7.5	10.3	...	9.3	7.1	9
Richmond	7.5	10.3	...	...	7.1	9.0
Albany	7.5	9.8	7	9.3	7	9
Binghamton	8.9	11.2	...	10.7	8.4	10.2
Buffalo	8.6	10.9	8	10.3	8.2	10
Jamestown	8.7	11	...	10.6	8.3	10
Mt. Vernon	7.6	10.3	...	9.4	7.2	9
Plattsburg	8.1	10.4	...	9.9	7.6	9.4
Rochester	8.7	11	7.9	10.2	7.9	9.7
Syracuse	8.5	10.8	7.8	10.1	7.8	9.6
Conn.:						
Bridgeport	7.8	10.3	...	....	7.2	8.8
Danbury	8.2	10.8	...	...	7.5	8.8
Hartford	8.0	10.5	...	9.5	7.2	9
New Haven	7.8	10.3	...	9.3	7	8.9
Maine:						
Bangor	7.9	10.2	7.4	9.7	7.4	9.1
Portland	7.5	10.2	7	9.3	7	9
Mass.:						
Boston	7.8	10.6	6.9	9.2	7.1	9
N. H.:						
Concord	8.4	10.7	...	....	8.2	10
Lancaster	9.5	11.8	...	....	9.2	11
Manchester	8.5	11.1	...	....	7.9	9.7
R. I.:						
Providence	7.6	9.9	6.9	9.2	7.1	8.9
Vermont:						
Burlington	8.1	10.4	7.5	9.8	7.5	9.2
Rutland	8.3	10.6	...	10	7.7	9.5

*Does not include 1% city sales tax applicable to price of gasoline (ex tax).

†In steel barrels.

Discounts: Diesel—On t.w. deliveries, 0.5c for at least 400 gals.; 1c for full tank truck.

	Bunker C Fuel Ships' bunkers (Ex Lighterage)	Diesel Oil Ships' bunkers (Ex Lighterage)	Diesel Oil Shore Plants	Gas House Gas Oil 28-34 Gravity
N. Y. Harbor	$1.65 –$2.07	$2.78	6.7–6.8 (2)	6.8 (2)
Albany	$1.85 –2.09(1)	$2.98 (1)	7 (1)	6.7 (1)
Philadelphia	$1.65 –$2.07	$2.78	....	....
Baltimore	$1.65 –$1.77	$2.78	6.7 (1)	6.7 (1)
Norfolk	$1.65 –$2.07	$2.78	6.7 (1)	6.7 (1)
Charleston	$1.60 –$2.02	$2.78 (2)	6.7 (1)	6.7 (1)
Savannah	$1.65–$1.72 (1)	$2.62 (1)	....	....
Jacksonville	$1.60–$2.02 (2)	$2.62 (2)	....	....
Tampa	$1.50 –$1.92	$2.62 (2)	....	....
New Orleans	$0.85–$1.27	$1.65 (1)	4 (1)	....
Portland	$1.65–$1.77	$2.86 (2)	7 (1)	6.9 (1)
Boston	$1.65–$1.77	$2.78	6.7 (2)	6.8 (2)
Providence	$1.65 –$2.07	$2.78 (2)	6.9 (1)	6.8 (1)

Residual fuel prices generally vary with A.P.I. specifications from range low for 9.9 & below degrees to range high for 25.0 & above.

Gulf Coast

Prices in Effect May 1

MOTOR GASOLINE	New Orleans & Lower Mississippi to Baton Rouge Tank Cars	New Orleans & Lower Mississippi to Baton Rouge Barge	Texas Gulf Coast South of New Orleans Tank Cars	Texas Gulf Coast South of New Orleans Barges	CARGOES Domestic & Export From all Gulf Ports
Leaded (oct. by ASTM)					
76 oct.	6.75	6.5 – 6.75	6.75 (2)	6.75 (2)	6.75
72 oct.	6.125	5.75	5.75	5.75	5.75
63-65 oct.	....	....	....	....	....
Unleaded 70 oct.	....	....	....	....	5.75
67-68 oct.	....	....	....	....	5.5
65 oct.	....	....	....	....	5.25
60 oct.	....	....	....	....	5
KEROSINE & LIGHT FUELS					
41-43 w.w. kero.	4.125–4.25	4.125	4.125– 4.25	4.125	4.125
42-44 w.w. kero.	....	....	4.125	4.125	4.125
No. 2 fuel oil	3.75	3.75	3.75 – 4	3.75	3.75
DIESEL & GAS OILS					
(In diesel index No.)					
Below 43 di.	....	....	....	....	....
43-47 di.	....	....	....	....	4
48-52 di.	4	4	4	....	4
53-57 di.	4.125	4.125	4.125	4.125	4.125
58 and above	4.25	4.25	4.25	....	4.25

HEAVY FUELS & BUNKER OILS In Cargoes (At all Gulf Ports) Heavy Diesels	In Ship's Bunkers (Ex-lighterage)
Below 28 API Grav.	$1.35
28 & above API Grav.	$1.65
Bunker C Oil	$0.85–$1.27

Above products in Truck Transports of 2,400 gal. and over ½c above Tank Car Prices.

NOTE—Prices for heavy fuels vary within the range given above according to gravity from 9.9 B grav. and below to 25 B and above.

Mid-Continent Lubes

(At Gulf; in packages, FAS.; in bulk, FOB terminals)

Prices in Effect May 1

	Steel Drums	Bulk
200 Vis. D 210 brt. stock	....	....
150 vis. D 210 brt. stock 0-10 p.p.	32.65(1&A)	24.8 (1)
10-25 p.p.	....	....
100 vis. D 210 brt. stock 0-10 p.p.	....	....
10-25 p.p.	....	....
200 vis. No. 3 col. neutral:		
0-10 p.p.	....	....

(A) FAS at New Orleans.

Wax

(Melting points are AMP, 3° higher than EMP. Prices are FOB refinery and do not include bag, freight or export differentials).

Prices In Effect May 1

Crude Scale	New Orleans Export	N. Y. Domestic	N. Y. Export
124-6 Yellow	4.25(1)	....	4.25(1)
122-4 White.	....	4.25(2)	4.25(2)
124-6 White.	4.25(1)	4.25	4.25
Fully Refined:			
123-5	5.2(1)	5.2(2)	5.2(1)
125-7	5.2(1)	5.2(2)	5.2(1)
128-30	5.6(1)	5.6	5.6(1)
130-32	5.85(1)	5.85(2)	5.85(1)
133-5	6.15(1)	6.15	6.15(1)
135-7	6.4(1)	6.4(1)	6.4(1)

Naphtha

Prices In Effect May 1

	V.M.&P. Naphtha	Mineral Spirits
New York Harbor	11 (2)	10
Philadelphia dist.	11 (2)	10
Baltimore	10.5 (2)	9.5
Boston	11.5 (2)	10.5
Providence	11.5 (1)	10.5 (2)

Prices in $ per bbl. of 42 U. S. gals. at the well. A. P. I. gravity. Prices are effective as of 7 a. m. of dates shown.

Oklahoma, Kansas, Texas & New Mexico Fields

(See below for companies posting and dates)

Gravity	Schedule A	Schedule B	Schedule C	Schedule D	Schedule E	Schedule F	Schedule G	Schedule H	Schedule J	Schedule K	Schedule M
Below 20	$1.08	$1.06	$1.03	$0.98	$0.93	....	....	....	$0.80	$0.80	$0.70
20-20.9	1.10	1.08	1.05	1.00	.95	....	....	....	.82	.82	.72
Below 21	....	....	....	....	....	....	....	$0.85	....	....	....
21-21.9	1.12	1.10	1.07	1.02	.97	....	....	.87	.84	.84	.74
22-22.9	1.14	1.12	1.09	1.04	.99	....	....	.89	.86	.86	.76
23-23.9	1.16	1.14	1.11	1.06	1.01	....	....	.91	.88	.88	.78
24-24.9	1.18	1.16	1.13	1.08	1.03	....	....	.93	.90	.90	.80
25 & above	....	....	....	....	....	....	....	....	....	.92	....
25-25.9	1.20	1.18	1.15	1.10	1.05	$0.97	$0.95	.95	.92	....	.82
26-26.9	1.22	1.20	1.17	1.12	1.07	.99	.97	.97	.94	....	.84
27-27.9	1.24	1.22	1.19	1.14	1.09	1.01	.99	.99	.96	....	.86
28-28.9	1.26	1.24	1.21	1.16	1.11	1.03	1.01	1.01	.98	....	.88
29-29.9	1.28	1.26	1.23	1.18	1.13	1.05	1.03	1.03	1.00	....	.90
30-30.9	1.30	1.28	1.25	1.20	1.15	1.07	1.05	1.05	1.02	....	.92
31-31.9	1.32	1.30	1.27	1.22	1.17	1.09	1.07	1.07	1.04	....	.94
32-32.9	1.34	1.32	1.29	1.24	1.19	1.11	1.09	1.09	1.06	....	.96
33-33.9	1.36	1.34	1.31	1.26	1.21	1.13	1.11	1.11	1.08	....	.98
34-34.9	1.38	1.36	1.33	1.28	1.23	1.15	1.13	1.13	1.10	....	1.00
35-35.9	1.40	1.38	1.35	1.30	1.25	1.17	1.15	1.15	1.12	....	1.02
36-36.9	1.42	1.40	1.37	1.32	1.27	1.19	1.17	1.17	1.14	....	1.04
37-37.9	1.44	1.42	1.39	1.34	1.29	1.21	1.19	1.19	1.16	....	1.06
38-38.9	1.46	1.44	1.41	1.36	1.31	1.23	1.21	1.21	1.18	....	1.08
39-39.9	1.48	1.46	1.43	1.38	1.33	1.25	1.23	1.23	1.20	....	1.10
40 & above	1.50	1.48	1.45	1.40	1.35	1.27	1.25	1.25	1.22	....	1.12

Posted by Carter Oil Co.

Schedule H includes Oklahoma and Kansas (Sept. 7, 1943).

Note: Besides other companies listed later, crude in Kansas and /or Oklahoma territory is purchased under Schedule H by Ben Franklin Refining Co. in Jefferson and Carter Counties, Oklahoma; by Rock Island Oil Co. in Stephens, Carter and Garvin Counties, Oklahoma; by Anderson-Pritchard Refining Corp. in Oklahoma City and Cement fields, starting with $0.70 for Below 16, with 3c differential for next four gravities (March 15, 1944); by Cosco Oil Co. and Standard Oil Co. of Indiana.

Posted by Humble Oil & Refining Co., June 16, 1943

Schedule A includes Refugio, Greta, Melon Creek, O'Connor-McFaddin, Plymouth, Taft, Tom O'Connor, and Refugio-Fox fields.
Schedule B includes Texas Gulf Coast, Amelia, Clear Lake, Goose Creek, Hastings, Magnet-Withers, Mykawa, Mykawa New, Raccoon Bend, South Thompsons, Sugarland, Thompsons, Webster, Danbury Dome and Lovell Lake.
Schedule C includes Mirando, Colorado, Comitas, Eagle Hill, Escobas, Glen, Government Wells (North & South), Heyser, Hoffman, Kelsey, Kohler, Loma Novia, Lundell, Manila, Randado, Sarnosa and Henne-Winch-Farris fields.
Schedule D includes Anahuac, Angleton, Cedar Point, Fishers, Reef, Hull, (Old & New), Pierce Junction, Red Rish Reef and Turtle Bay fields.
Schedule E includes Dickinson, Gillock, Hardin, Rowan, Danbury and Danbury Dome, 5,655 ft. sand.
Schedule F includes East Central Texas, Anderson, Cherokee, Limestone & Navarro Counties and Navarro Crossing.
Schedule G includes West Central Texas, Brown, Callahan, Comanche, Eastland, Fisher, Haskell, Jones, Shackelford, Stephens & Throckmorton Counties.
Schedule J includes Panhandle, Texas, Carson, Gray, Hutchinson & Wheeler Counties.
Schedule K includes Hawkins and Talco fields.
Schedule M includes West Texas & New Mexico, Andrews, Crane, Crockett, Ector, Gaines, Glasscock, Howard Reagan, Upton, Winkler & Yoakum Counties, Texas; Lea County, N. M.

Clark, Zoboroski	$1.14
Sun	1.35
Yates (Pecos)	0.95
Conroe	1.43
Tomball	1.40
Van	1.08
Bazette, East Texas & Flag Lake	1.25
La Rosa, Flour Bluff, E. Flour Bluff	1.33
Salt Flat, N. Salt Flat	1.14
Darst Creek, Hilbig	1.14
Lentz & Tenney Creek	1.14

Posted by Magnolia Petroleum Co.

Schedule C includes Mirando, Texas (May 21, 1941).
Schedule H includes Oklahoma (Oct. 1, 1943) beginning with Below 21, and North and North Central Texas (May 22, 1943) beginning with Below 29 at $1.01.
Schedule J includes Panhandle Texas, beginning with Below 29 at $0.98 (June 16, 1943).
Schedule K is for Talco crude (May 28, 1943).
Schedule M includes West Texas in Crane, Upton, Howard, Glasscock, Mitchell, Winkler, Cochran, Hockley, Yoakum and Gaines Counties, and in Pecos and Andrews Counties and New Mexico in Lea County, beginning with Below 20 and ending with 40 and Above (Jan. 1, 1944). Cass and Panola Counties, Texas, schedule (May 21, 1941) begins with Below 25 at $0.88 with 2c differential.

East Texas	$1.25
Darst Creek	1.14
Luling	1.05
Lytton Springs	1.17
Cleveland-Liberty	1.26
Tomball	1.40

Posted by Sinclair-Prairie Oil Marketing Co.

Schedule A includes Wade City and Clara Driscoll (Jan. 1, 1943).
Schedule B includes Texas Gulf Coast (May 21, 1941).
Schedule C includes Mirando, Texas (Nov. 1, 1942).
Schedule F includes Mexia district, Texas, beginning with Below 25 at $0.95 (May 30, 1941).
Schedule H includes Oklahoma and Kansas (May 20, 1941) and North Central Texas (May 22, 1943) beginning with 25-25.9 at $0.95.
Schedule M includes West Texas and New Mexico beginning with Below 25 at $0.80 (May 30, 1941)

East Texas	$1.25
Long Lake, Texas	1.23
Chapel Hill, Washington County, Texas:	
Below 50 gravity (Jan. 20, 1942)	1.18
50 gravity and above (Feb. 2, 1942)	1.25
Alfred and Magnolia City	1.35
Alice, Ben Bolt, Tom Graham	1.35
Agua Dulce	1.35
Cadena	1.35
Flour Bluff, E. Flour Bluff	1.33

Posted by Stanolind Oil Purchasing Co.

Schedule B includes Dyersdale, Trinity (Kittrell), W. Beaumont, Lake Creek, Clinton and Pinehurst fields, all in Texas, the last three beginning with Below 21 at $1.08.
Schedule E includes Fairbanks, N. Houston, Rosslyn, Aldine and Clodine fields, Texas Gulf Coast.
Schedule H is for North Texas crude (May 22, 1943).
Schedule M is for Slaughter and Cedar Lake fields in West Texas (May 1, 1943).

East Texas	$1.25
Satsuma and Tomball, Texas	1.40
Eureka Heights, Harris County	1.15

Posted by Stanolind Oil & Gas Co.

Schedule B includes Spindletop, Jefferson County and High Island, Galveston County, Texas.
Schedule D includes Jay Welder, Calhoun County, Texas.
Schedule M includes Spencer and Pyote fields, Ward County, Texas and Magnolia, Sealey South field in Ward County, ending with 36 & Abov. at $1.04. Also Hendrick and Henderson, Winkler County, Texas, beginning with Below 26 at $0.82.

Posted by The Texas Company (Jan. 1, 1944)

Schedule A is for Saxet field, ending with 28-28.9 at $1.26.
Schedule B includes Texas Gulf Coast, ending with 34 & Above at $1.36.
Schedule C includes Duval Mirando, Texas, ending with 28-28.9 at $1.21.
Schedule H includes Oklahoma and Kansas, and North and North Central Texas.
Schedule J is for Panhandle Texas, beginning with 34-34.9 at $1.10.
Schedule M includes West Texas and Lea County, New Mexico, beginning with Below 20 and ending with 40 & Above.

East Texas	$1.25
Darst Creek	1.14
Conroe	1.43

Posted by Shell Oil Co., Inc. (May 22, 1943)

Schedule H includes Oklahoma and Kansas crude, bought by Shell Oil Co., Tulsa (Oct. 1, 1943) and Fisher County, Texas, crude, bought by Shell Oil Co., Houston, beginning with 30-30.9 at $1.05.
Schedule M includes West Texas and Lea County, New Mexico, ending with 40 & Above at $1.12 (Dec. 1, 1943).

East Texas	$1.25
Livingston field, Polk County	1.25
Pecos County, Texas (except Yates shallow pool)	.95
Pecos County, Texas, Yates shallow pool	.82
Mercy field, San Jacinto County	1.25

Posted by Continental Oil Co. (June 16, 1943

Schedule H includes Oklahoma, Kansas and North Texas crudes, beginning with Below 29 at $1.01.
Schedule J includes Carson and Hutchinson Counties, Texas, beginning with 29-29.9 at $1.00.
Schedule M includes Eddy County, New Mexico, beginning with Below 29 at $0.88.
Rincon & Cameron, Texas, schedule begins with Below 29 at $1.21 with 2c differential and ends with 40 & above at $1.45.

Posted by Gulf Refining Co.

Schedule for New Hope, Franklin County, Texas, begins with Below 25 at $0.88 and ends with 40 & Above at $1.20 (Aug. 5, 1943).

Posted by Pan American Production Co. (Nov. 1, 1943)

Schedule B includes Hastings, South Houston and Chocolate Bayou distillate, beginning with Below 21 at $1.08.
Schedule D includes Alta Loma crude oil.
Schedule E includes Gillock-Dickinson, League City and Chocolate Bayou crude oil, beginning with Below 21 at $0.95.

East Texas	$1.25
Cayuga, Texas	.90
Goodrich, Texas	1.20

Pennsylvania Grade

Posted by Jos. Seep Purch. Agency (Mar. 26, '42)

Bradford-Allegany	$3.00
Southwest Penna	$2.65
Eureka (West Va.)	$2.59
Corning, O. (May 27, '41)	$1.31
Posted by The Pennzoil Co. (Mar. 26, '41)	
National Transit	$2.93*
Posted by Valvoline Pipe Lines (Mar. 26, '42)	
Bradford (Elk & McKean Counties, Pa.)	$3.00
Warren, Forest, Venango, Clarion & Butler Counties, Pa.	$2.93
Alleghany, Beaver, Washington & Greene Counties, Pa.	$2.65
West Virginia	$2.59
Southeastern Ohio	$2.55

*Applies to Cochran, Franklin, Hamilton & Doolittle districts; prices in other lower districts range down to $2.88 per bbl. at well.

Michigan

Posted by Pure Oil Co.

Midland, Mecosta	$1.44
Sherman, Freeman, Temple, Reed City	$1.39
Arenac, Adams	$1.27
Goodwell	$1.48

Posted by Simrall Corp. (May 27, '41)

Greendale, Porter, Vernon, Crystal & Wise	$1.44
Buckeye, Bentley, Edenville, Beaverton & Monitor (sweet crude type)	$1.42
Freeman, Redding, Lincoln & Winterfield	$1.39
West Branch-Arenac	$1.24
Hamilton-Grout	$1.29
(April 1, 1944)	
Fork Tws.-Mecosta Co.	$1.44

Posted by Sohio Corp. (Mich. Div.)

Traverse crude in Allegan, Kent, Ottawa & Van Buren Cos. (June 2, '41) $1.45
Trenton crude, Monroe Co. (June 2, '41) $1.39

Posted by Bay Pipe Line Corp. (May 27, '41)

Saginaw & Wise	$1.44	Buckeye, Bentley & Kawkawin	$1.42
Clare	$1.11	Adams (June 1, '41)	$1.27

Illinois-Indiana-Kentucky-Ohio

Posted by Sohio Corp. (May 21, '41)

Illinois Basin*, including Griffin pool	$1.37
Carmi, Storms, Ill. area	$1.37
Birk City, Ky. area (July 1, '43)	$1.37
Western Kentucky (Dec. 1, '43)	$1.37

Posted by Ohio Oil Co. (May 21, '41)

Illinois Basin	$1.37
Eastern Ill. & Western Ind.	$1.22

Posted by Carter Oil Co. (May 21, '41)

Loudon, Fayette Co. Ill.	$1.37

Posted by Mohawk Oil Lines, Inc. (May 21, '41)

Southern Illinois	$1.37

Posted by Ashland Oil & Transp. Co. Somerset oil in Ash. Lines, Ky.

Big Sandy River $1.38 Kentucky River $1.43

Posted by Owensboro-Ashland Co.

Owensboro, Ky. area (July 1, '43)	$1.37

Posted by S. O. Ohio (Sept. 1, '41)

Lima, Ohio	$1.50
Cleveland, Lodi & Chatham (O.) areas	$1.30

*Also posted by The Texas Co.

CRUDE OIL PRICES (Continued)

Prices in $ per bbl. of 42 U. S. gals. at the well. A. P. I. gravity. Prices are effective as of 7 a.m. of dates shown.

Louisiana, Arkansas, Southeastern, Rocky Mountain Fields

(See below for companies posting and dates)

Gravity:	A Schedule	B Schedule	C Schedule	D Schedule	E Schedule	F Schedule	G Schedule	H Schedule	J Schedule	K Schedule	M Schedule
Below 20	....	....	....	....	....	....	$1.06	$0.99	$0.94	$0.89	....
20-20.9	$0.68	....	$0.80	....	....	$0.90	1.08	1.01	.96	.91	....
21-21.9	.70	....	.82	....	....	.92	1.10	1.03	.98	.93	....
22-22.9	.72	....	.84	....	....	.94	1.12	1.05	1.00	.95	....
23-23.9	.74	....	.86	....	....	.96	1.14	1.07	1.02	.97	....
24-24.9	.76	$0.86	.88	$1.03	....	.98	1.16	1.09	1.04	.99	$0.86
25-25.9	.78	.88	.90	1.05	....	1.00	1.18	1.11	1.06	1.01	.88
26-26.9	.80	.90	.92	1.07	....	1.02	1.20	1.13	1.08	1.03	.90
27-27.9	.82	.92	.94	1.09	....	1.04	1.22	1.15	1.10	1.05	.92
28-28.9	.84	.94	.96	1.11	....	1.06	1.24	1.17	1.12	1.07	.94
29-29.9	.86	.96	.98	1.13	....	1.08	1.26	1.19	1.14	1.09	.96
30-30.9	.88	.98	1.00	1.15	$1.05	1.10	1.28	1.21	1.16	1.11	.98
31-31.9	.90	1.00	1.02	1.17	1.07	1.12	1.30	1.23	1.18	1.13	1.00
32-32.9	.92	1.02	1.04	1.19	1.09	1.14	1.32	1.25	1.20	1.15	1.02
33-33.2	.94	1.04	1.06	1.21	1.11	1.16	1.34	1.27	1.22	1.17	1.04
34 & Above	....	....	....	....	....	....	....	1.29	1.24	1.19	....
34-34.9	.96	1.06	1.08	1.23	1.13	1.18	1.36	....	....	....	1.06
35-35.9	.98	1.08	1.10	1.25	1.15	1.20	1.38	....	....	....	1.08
36-36.9	1.00	1.10	1.12	1.27	1.17	1.22	1.40	....	....	....	1.10
37-37.9	1.02	1.12	1.14	1.29	1.19	1.24	1.42	....	....	....	1.12
38-38.9	1.04	1.14	1.16	1.31	1.21	1.26	1.44	....	....	....	1.14
39-39.9	1.06	1.16	1.18	1.33	1.23	1.28	1.46	....	....	....	1.16
40 & Above	1.08	1.18	1.20	1.35	1.25	1.30	1.48	....	....	....	1.18

Canadian Fields

Posted by Imperial Oil Limited
Western Ontario (Dec. 16, 1942)

Oil Springs.....$2.42
Petrolia.....$2.35

Turner Valley Crude Oil
(April 1, '43)
(Prices FOB producer's tankage)

33-33.9..$1.50	49-49.9..$1.82
34-34.9.. 1.52	50-50.9.. 1.84
35-35.9.. 1.54	51-51.9.. 1.86
36-36.9.. 1.56	52-52.9.. 1.88
37-37.9.. 1.58	53-53.9.. 1.90
38-38.9.. 1.60	54-54.9.. 1.92
39-39.9.. 1.62	55-55.9.. 1.94
40-40.9.. 1.64	56-56.9.. 1.96
41-41.9.. 1.66	57-57.9.. 1.98
42-42.9.. 1.68	58-58.9.. 2.00
43-43.9.. 1.70	59-59.9.. 2.02
44-44.9.. 1.72	60-60.9.. 2.04
45-45.9.. 1.74	61-61.9.. 2.06
46-46.9.. 1.76	62-62.9.. 2.08
47-47.9.. 1.78	63-63.9.. 2.11
48-48.9.. 1.80	64 & over 2.12

Louisiana-Arkansas Fields

Posted by S.O. Louisiana
(Feb. 3, 1943)

Schedule A, Arkansas Sour, includes Atlanta, Buckner, Magnolia, Patton, Schuler (Jones Sand), and Village fields.

Schedule B, North Louisiana-Arkansas Sweet, includes De Soto and Sabine Parishes (La.), Fouke (Ark.), Homer (La.), Miller County (Ark.) and Sugar Creek (La.) fields. Also Central Louisiana crudes including Catahoula Lake, Cypress Bayou, Elm Ridge, Hemphill, Holly Ridge (a), Indian Bayou, Lake Larto, Lake St. John (4500 ft. horizon) and Nebo fields.

Schedule C, North Louisiana-Arkansas Sweet, includes Caddo (La.), Cotton Valley (La.), Rodessa (La.-Ark.), and Shreveport (Cross Lake) (La.) fields, beginning with 24-24.9 at $0.88.

Schedule D, Central Louisiana, includes Lake St. John (3500 ft. horizon), Little Creek, Olla and South Olla fields.

Schedule E applies to Golden Meadow field and to Westwego, beginning with below 31.

Schedule F, South Louisiana, includes Bayou Mallet, Bayou Sale, Bunkie, Choctaw, Darrow, Eola, Jeanerette, Lirette, North Crowley, Pine Prairie, Port Allen, Port Barre, Potash, Roanoke, St. Martinville, South Crowley and University (deep production) fields. Also (beginning Jan. 12, 1943), Bayou des Allemands, Branch, Hope Villa, Krotz Springs, Lake Chicot, Lewisburg, Napoleonville, Raceland, Reddell and Rossdale fields. Also applies to Anse La Butte field in South Louisiana, beginning with 20-20.9 at $0.90.

Schedule G applies to University (shallow production) field.

South Arkansas Sweet Distillate, Dorcheat and Macedonia.....$1.25
Arkansas Sour Distillate, Big Creek, Columbia, Dorcheat, Macedonia and McKamie 1.25
Lisbon Distillate..... 1.20
Cotton Valley Distillate..... 1.40
Cotton Valley Crude (Holloway Sand)... 1.25

Note: Identical schedules, except for starting and ending points, are posted in areas affected by Arkansas Fuel Oil Corp., A, C, and D; Smackover, $0.98; Stanolind Oil & Gas Co., C, E. (Acadia Parish) and G (Hackberry); Texas Co., C, E, and F; Pan American Production Co. and Pure Oil Co., F.

Posted by Cont nental Oil Co.
(Jan. 12, 1944)

Schedule F is for Abbeville, Tepetate, Lake Arthur and North Tepetate Louisiana crudes.
Bear, Ville Platte and West Mermentau...$1.30

Posted by Shell Oil Co., Inc.
(Dec. 1, 1943)

Schedule F (Feb. 1, 1944) is for crude purchased in Gibson field, Louisiana Gulf Coast, beginning with Below 20 at $0.88 and ending with 40 and Above.

Schedule H is for crude purchased in Iowa, Black Bayou and White Castle fields, Louisiana Gulf Coast.

Schedule J is for crude purchased in Roanoke and Chalkley fields, Louisiana Gulf Coast.

Schedule K is for crude purchased in South Houma and West Lake Verret fields, Louisiana Gulf Coast.

Happytown field, St. Martin Parish, La...$1.15

Rocky Mountain Fields

Posted by Stanolind Oil & Gas Co.

Salt Creek field, Wyoming, excepting Tensleep crude (Feb. 12, 1944). Begins with Below 21 at $0.85 with 2c differential and ends with 40 and Above at $1.25.

Midway field, Wyoming, Schedule C.

Tensleep (Salt Creek) Wyo. $0.8285	Grass Creek, Wyo., Light.....$1.00
Tensleep (Elk Basin) Wyo... .90	Grass Creek Heavy..... .65
Frannie Light... .85	Elk Basin, Wyo. 1.00
Frannie Heavy.. .62	Iles, Colo..... 1.07

Posted by Carter Oil Co.

Cut Bank pool, Montana (Jan. 1, 1944)...$1.30
Darling pool, Montana (Jan. 1, 1944)..... 1.10

Posted by Continental Oil Co. (June 16, '43)

Schedule C includes Ft. Collins and Wellington, Colo., crudes with the addition of Below 29 at $0.96.

Canon City & Florence, Colo....$1.05	Big Muddy, Wyo.$1.08
Cat Creek, Mont. 1.15	Lance Creek, Wyo..... 1.12

Posted by Ohio Oil Co.

Wyoming Crudes:	
Elk Basin Light $1.00	Rock Creek.....$1.15
Elk Basin Heavy .90	Lance Creek..... 1.12
Grass Creek Light 1.00	Oregon Basin.... .65
Grass Creek Hvy. .65	Garland..... .60
	Byron..... .70

Posted by Independent Pipe Line Co.

Falls City, Nebr., field price.....$0.90
Falls City, loaded in tank cars..... .95

California

Posted by S. O. California, May 25, 1943 (*All gravities above those quoted take highest price offered in that field*)

Gravity	Signal Hill (Long Beach)	Wilmington	El Segundo	Seal Beach	Huntington Beach	Inglewood	Olinda Brea Canon	Athens-Rosecrans	Torrance	Richfield	Whittier East Coyote (La Habra)	Montebello	West Coyote Hills	Santa Fe Springs	Greeley, Canal, Wasco	Coles Levee	Mountain View	Elk Hills, Buena Vista Hills Midway-Sunset, Lakeview Area	Lost Hills	Coalinga
14-14.9	....	$0.93	....	....	$0.96	....	$0.95	....	$0.95	$0.95	$0.95	$0.97	....	....	....	....	....	$0.98	$0.98	$0.98
15-15.9	....	.96	....	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	....	.98	.98	.98
16-16.9	....	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	....	.98	.98	.98
17-17.9	....	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	....	.98	.98	.98
18-18.9	$0.93	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	....	.98	.98	.98
19-19.9	.93	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	$0.98	.98	.98	.98
20-20.9	.93	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	.98	.98	.98	.98
21-21.9	.93	.96	1.01	....	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	.98	.98	.98	.98
22-22.9	.96	.98	1.02	.88	1.00	1.01	.97	....	.97	.96	.97	.97	....	....	....	....	.98	.98	.98	.98
23-23.9	1.00	1.02	1.05	.92	1.02	1.01	.98	....	.97	.98	1.00	.97	....	....	....	....	.99	.99	.98	.98
24-24.9	1.03	1.06	1.07	.97	1.05	1.04	1.01	....	1.01	1.02	1.03	.97	$0.99	....	....	....	1.03	1.03	.99	.98
25-25.9	1.07	1.09	1.10	1.01	1.08	1.07	1.04	....	1.05	1.06	1.07	.98	1.02	....	....	....	1.07	1.07	1.01	.98
26-26.9	1.11	1.12	1.12	1.06	1.11	1.10	1.08	....	1.09	1.10	1.11	1.01	1.06	....	....	....	1.11	1.11	1.04	.98
27-27.9	1.15	1.15	1.15	1.10	1.14	1.14	1.11	....	1.13	....	1.15	1.05	1.10	1.04	....	....	1.15	1.15	1.07	.98
28-28.9	1.18	1.18	1.17	1.15	1.17	1.17	1.14	....	1.17	....	....	1.08	1.13	1.08	....	....	1.19	1.19	1.10	1.00
29-29.9	1.20	1.21	....	1.19	1.20	1.20	....	1.17	....	....	....	1.12	1.17	1.12	....	....	1.24	1.24	1.13	1.02
30-30.9	1.23	1.24	....	....	1.23	1.22	....	1.21	....	....	....	1.15	1.21	1.15	$1.01	$1.09	1.28	1.28	1.16	1.04
31-31.9	....	....	....	....	....	1.24	....	1.25	....	....	....	1.19	1.24	1.19	1.04	1.12	....	....	....	1.06
32-32.9	....	....	....	....	....	....	....	1.29	....	....	....	1.23	1.28	1.23	1.07	1.14	....	....	....	1.09
33-33.9	....	....	....	....	....	....	....	1.32	....	....	....	1.27	....	1.26	1.10	1.17	....	....	....	1.11
34-34.9	**Kettleman Hills**		....	....	....	....	....	1.36	....	....	....	1.31	....	1.30	1.13	1.20	....	....	....	1.13
35-35.9	....	$1.23	....	....	....	....	....	....	....	....	....	1.35	....	....	1.16	1.22	....	....	....	....
36-36.9	....	1.26	....	....	....	....	....	....	....	....	....	1.39	....	....	1.19	1.25	....	....	....	....
37-37.9	....	1.29	....	....	....	....	....	....	....	....	....	1.43	....	....	1.22	....	....	....	....	....
38-38.9	....	....	....	....	....	....	....	....	....	....	....	1.47	....	....	1.25	....	....	....	....	....
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40-40.9	....	....	....	....	....	....	....	....	....	....	....	1.53	....	....	....	....	....	....	....	....

Wheeler Ridge: $0.95 for 22-22.9; 23-23.9, 24-24.9. **Newhall, Kern River, Kern Front, McKittrick & Round Mountain:** 12-12.9, $0.94; 13-13.9, $0.96; 14-14.9, $0.98. **Elk Hills, Buena Vista Hills, Midway-Sunset, Lake View Area, Lost Hills and Coalinga:** 12-12.9, $0.94; 13-13.9, $0.96. **Elwood Terrace:** 33-33.9, $1.22; 34-34.9, $1.25; 35-35.9, $1.28. **Gato Ridge:** 12-12.9, $0.74; 13-13.9, $0.76; 14-14.9, $0.78; 15-15.9, $0.80.

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FOR SALE: W. A. 20, 1942 White tractor, 900x20 tires, 3800 Fruehauf trailer, 1000x20 tires all practically new. Good clean outfit. Glenn Oil Co., Muncie, Ind.

FOR SALE in Detroit, Michigan—Bulk Plant 120,000 gallon storage. Building prox. 65 x 65 feet square, 2 gasoline stations, large storage. Price $50,000 terms can be arranged. Box No. 379.

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CONTAINERS—About 18,000, used, rectangular, 14 gauge, galvanized steel, weight about 40 lbs., 28¼ x 16¼ x 9¾ in., 6-in. diameter opening with grip-lock closure, capacity about 15 liquid gallons. Price 90c each f.o.b. car Omaha, Neb., carload lots. Wm. H. Muller & Co., 122 East 42nd St., New York 17, N. Y.

WAREHOUSE SALE for storage charges 119 Drums Western Lubricating Oils Grades SAE 20-30-40 at 29c per gallon, tax paid and including drum F O B Detroit, Michigan. Box No. 382.

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150 Tanks 500—5,000,000 gallon capacity.

8 Viking pumps 2″ and 3″ single and dual.

Write, wire, phone for prices.

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800 Gallon Gasoline Tank with four compartments, for delivery truck, reasonably priced. Or will trade same out in lubricating oils at bulk prices or would trade on a four thousand gallon tank.

Independent Oil Co.,
220 Spring St., Charleston, S. C.

FOR SALE

One 1940 White gasoline transport, model 810 C. O. E., 356 cubic inch motor, 1000-20-tires. Westinghouse air brakes throughout, cab control, foot valve, 2 speed axles—power take off—3 compartment tractor tank and 3 compartment pup trailer tank—over all capacity 4645 gallon. Complete outfit in perfect mechanical condition good tires throughout.

Cole and Myers Oil Co.,
Bethany, Mo.

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WANTED: Two-speed Eaton or Timken, 18,000 pound rear axle assembly housing complete. Venable Oil Company, Carterville, Ill.

WANTED: Lowest prices quoted us on bulk and canned lubricating oils in quantity, also fuel oils and kerosene. Independent Oil Co., 220 Spring St., Charleston, S. C.

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OIL MAN in this country since 1941; formerly sales manager European oil refinery for many years. Age 42; unattached; has lectured in this country; also did work for U. S. government. Seeks position where his experience and abilities can be utilized. Highest references. Box No. 381.

BULK PLANT MANAGER — 15,000 population, ten years major oil company experience, good merchandiser, available at once. Willing to make connection any part of country. 45 years old. References exchanged.

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Box No. 377

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WANTED

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Apply to Box No. 366

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The ARABIAN AMERICAN OIL COMPANY is interested in receiving applications from technically educated men and/or men with oil field experience, for work in Saudi Arabia. This offers a splendid opportunity for advancement and post war security, with good working conditions, hospital and medical care, liberal benefit plans, and vacation privileges in the United States.

WRITE OR APPLY TO OUR RELATIONS DEPARTMENT, 200 Bush Street, San Francisco.

National Petroleum News

Established February, 1909

Published every Wednesday by
The National Petroleum Publishing Co.

WARREN C. PLATT, *Editor and Publisher*
A. E. KRAFT, *Treasurer*
V. B. GUTHRIE, *Associate and Technical Editor*
V. C. REPPETO, *Managing Editor*
Y. A. KOSKINEN, *Advertising Manager*

Member of
Audit Bureau of Circulation
and Associated Business
Papers, Inc.

Publication office: 1213 W. Third St., Cleveland 13, Ohio, U. S. A. Telephone, CHerry 7672. Cable Address PLATTOIL, Cleveland. Cable inquiries are answered by mail unless subscriber advances sufficient funds in American money to cover our cable cost.

NEWS BUREAUS

New York 20, 50 W. 50th Street, Telephone Columbus 5-1516 and 5-1517.
Washington 4, D. C., 1034-36-38 National Press Bldg., Telephone NAtional 3477.
Tulsa 3, Okla., 904 World Bldg., Telephone 3-7132.
Los Angeles 14, 610-A Hillstreet Bldg., Telephone VAndike 2845.
Chicago 5, 59 E. Van Buren Street, Telephone HARrison 5901-2-3.

Subscription rate $5 per year in United States, Mexico and Pan-American Countries; $6.50 in Canada and Foreign Countries. Current copies 20 cents, except special issues; back copies more than two months old 30 cents per copy.

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Trade Mark Registered U. S. Patent Office

Classified Rates

"For Sale," "Wanted to Buy," "Help Wanted," "Business Opportunities," "Miscellaneous" classifications, set in type this size without border—15 cents a word. Minimum charge, $4.00 per insertion.

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ABOUT OIL PEOPLE

Mr. Carringer

J. R. Carringer, vice president of Standard Oil Co. (N. J.) was recently honored at the semi-annual conference of supervisors and foremen of the New Jersey refineries at Elizabeth, N. J., on completion of 40 years with the company.

Mr. Carringer joined the company in 1903, working in a tank car repair shop. He was named general superintendent of the Bayway, N. J., refinery in 1921 and assistant general manager of all New Jersey refineries in 1933 and subsequently became general manager of manufacturing operations.

He was elected a director of the company in 1940 and became vice president in 1943.

* * *

Holiday greetings have been received by NPN from **Sreepaty Bros.,** Bezwada, India. The greetings postmarked Dec. 31, arrived in Cleveland April 15.

* * *

S. B. Irelan was elected president and director of Cities Service Gas Co. at a recent meeting of the board of directors following the resignations of **H. R. Straight,** president and director, and **A. W. Ambrose,** vice president and director.

Mr. Straight said that his increasing duties as president and those of Mr. Ambrose as executive vice president of Cities Service Oil Co. in its expansion of diversified oil production, refining and marketing activities, would take all their time. They will continue in their offices of Cities Service Oil Co.

For the past 35 years Mr. Irelan has been associated with various subsidiaries of Cities Service Co. He has been vice president in charge of property valuation and refinancing of subsidiary public utility companies of Cities Service Power and Light Co. for the past several years.

* * *

Kenneth A. Ackley has been named chief oil scout of The Carter Oil Co., replacing **Wayne W. Breedlove,** who has resigned to accept a position with the Mid-Continent Map Co. Mr. Ackley, with Carter since 1937, was employed in sub-surface geological work in Oklahoma and Illinois until transferred to Baton Rouge, La., where he has been crude oil scout since 1942.

John W. Glahn, district man for Cities Service Oil Co., Midland, Tex., for the past year, has resigned to become an independent operator. Mr. Glahn, who formerly was connected with the company at Fort Worth and Houston, has been with Cities Service and the Indiana Territories Illuminating Oil Co. for 14 years.

* * *

J. C. Williamson, district geologist in West Texas and Southeast New Mexico for Phillips Petroleum Co., has opened an office in Midland, Tex., to practice as a consulting geologist.

Ed A. McCullough, member of Phillips' scientific staff, is acting district geologist since Mr. Williamson's resignation.

* * *

C. P. Watson of Seaboard Oil Co. was elected president of the Oil Producers Agency of California at its annual meeting in Los Angeles. **W. C. Whaley** of Barnsdall Oil was elected first vice-president, **H. E. Woodworth** of Safe Oil second vice-president, **R. H. Garrison** of Hellman Estate, third vice-president, and **C. C. Sprice** of Republic Oil, fourth vice-president. **Rush M. Blodgett** of Blackfoot Petroleum was re-elected executive vice-president.

* * *

Maj. Jerry Sadler, former railroad commissioner of Texas, has been awarded the Soviet decoration of Order of the Fatherland's War, second class, Austin, Tex., friends have learned.

Maj. Sadler, who has been in the Persian Gulf area expediting war supplies to Russia, was among the officers and four enlisted men decorated by the Soviet government.

* * *

I. E. Swensrud, with W. H. Barber Co. for the past three years, lately as territory salesman, has left for military service. **S. E. Rice,** formerly an official of National Auto Supply Co. and more recently owner of the S. E. Rice Accessory Co., Rockford, Ill., is now with the Barber Co. as special representative. No replacement has as yet been made for Mr. Swensrud.

* * *

Winston P. Henry, independent oil operator, has been named director of Houston's Fifth War Loan drive, June 12 to July 8. Mr. Henry also served as director of the Fourth War Loan when more than $79,000,000 in government securities were sold.

Joseph M. Alexander of Globe Oil & Refining Co.'s Chicago office wholesale order and shipping department, who recently passed his pre-induction physical examination, is awaiting notification from the Army to report.

* * *

Luther Williams, assistant advertising manager of the Mid-Continent Petroleum Corp., and editor of *The Diamond,* employe magazine, has resigned to accept a position as junior account executive with the Griswold-Eshleman Co., Cleveland, Ohio, advertising agency. Mr. Williams has been identified with numerous civic projects in Tulsa and the highlight of his civic recognition came in 1936 when he received the city's "Distinguished Service Award" for his direction of a campaign which led to the city's model street marker and identification system. He served two terms as a director of the National Junior Chamber of Commerce.

* * *

Service awards for 25-year or longer service with The Texas Co. were presented to 97 company employes at a dinner of the Texaco Old Timers Club.

J. Sayles Leach, club vice-president, presented the awards, and **A. M. Donoghue,** president, presided. Twenty awards went to employees completing 30 years and 77 to 25-year men. It was announced that 2800 employees had completed 25 or more years of service with The Texas Co.; 594 have completed 30 years or more; 113 more than 35 years; 9 40 years or more, and one, **Ira McFarland,** comptroller has 42 years' service. He joined the company on its organization in 1902.

* * *

Mr. Clarisey

W. A. Clarisey, assistant district manager of the Socony-Vacuum Oil Co., Inc., in Grand Rapids, Mich., since 1939, has been appointed western district manager of the company. His territory includes western Michigan. He joined the company in 1927 as sales manager in the Soo and was promoted to zone manager in 1935.

Mr. Clarisey succeeds **L. B. Page,** who has been granted a leave of absence to join the U. S. Navy as a lieutenant, stationed in Washington, D. C. His successor as assistant district manager is **William Banninga,** who during his 10 years with the company has held numerous territorial responsibilities and served in supervisory capacities for the past two years.

YESTERDAY

good gasoline pumps

Official U. S. Marine Corps Photo.

TODAY

shells to pound the enemy... tomorrow, the finest pumps made

When the first shots of war rang out, the production of precision made M & S pumps went out for the duration. Today our skill, productive equipment, and "know-how" are producing shells for our boys to pump into the enemy.

But to the service station operators throughout the nation, M & S pumps are still on the job . . . fueling the vital transportation units of the Nation. Thousands upon thousands of these sturdy pumps of yesterday are giving unfailing service without breakdowns, without need of spare parts, without unnecessary replacements.

And when peace comes again, tomorrow's M & S pumps will be the finest we've ever made. Pumps with more eye-appeal and greater visibility. Pumps that display and help sell other products. Pumps that "fill 'em up faster" to save customers' and attendants' time. Pumps that last longer and can be kept cleaner.

Look to M & S for the pumps of tomorrow

MARTIN & SCHWARTZ *pumps*

SALISBURY, MARYLAND

FLEET-WING PRODUCTS

..the Jobber Brand

THE BAYONET—
WAR WEAPON OF THE OIL
INDUSTRY

WARTIME driving restrictions—infrequent use of cars, short trips, slow speeds, subnormal engine temperatures—are direct causes of more than usual engine wear and damage. Under these conditions, engine acids and varnishes, carbon and sludge formations are more prevalent than ever before. Today, engine sludge is one of the most active saboteurs of America's transportation system.

The oil industry from the top right down to the man at the pump has the responsibility of awakening America's car drivers to the danger, and furnishing remedies.

A sensible and practical way to start is with the oil bayonet—the oil dip stick that shows oil level and often discloses the presence of abrasive grit and droplets of water. Where there is water (and regardless of quality of oil used), there is every chance of sludge formation being present to waste power and gasoline, and ruin engines.

It is a big job for the whole oil industry—this conservation of America's cars and motor fuels. The practical way to tackle it is really to help the service station man who talks right to the car owners and does the servicing and maintenance jobs.

Fleet-Wing, this Spring, through its independent jobbers, is giving every Fleet-Wing dealer technical information and graphic, point-of-sale display material to support an anti-sludge campaign that is timely, patriotic—and, incidentally, profitable to every jobber and the dealer who takes advantage of this opportunity.

GASOLINE POWERS THE ATTACK — DON'T WASTE A DROP

FLEET-WING CORPORATION
1025 REPUBLIC BUILDING CLEVELAND OHIO

TECHNOLOGY DEPT.

NATIONAL PETROLEUM NEWS

Monthly Technical Section Devoted to

REFINERY MANAGEMENT *and* **PETROLEUM CHEMICAL TECHNOLOGY**

Section Two **May 3, 1944**

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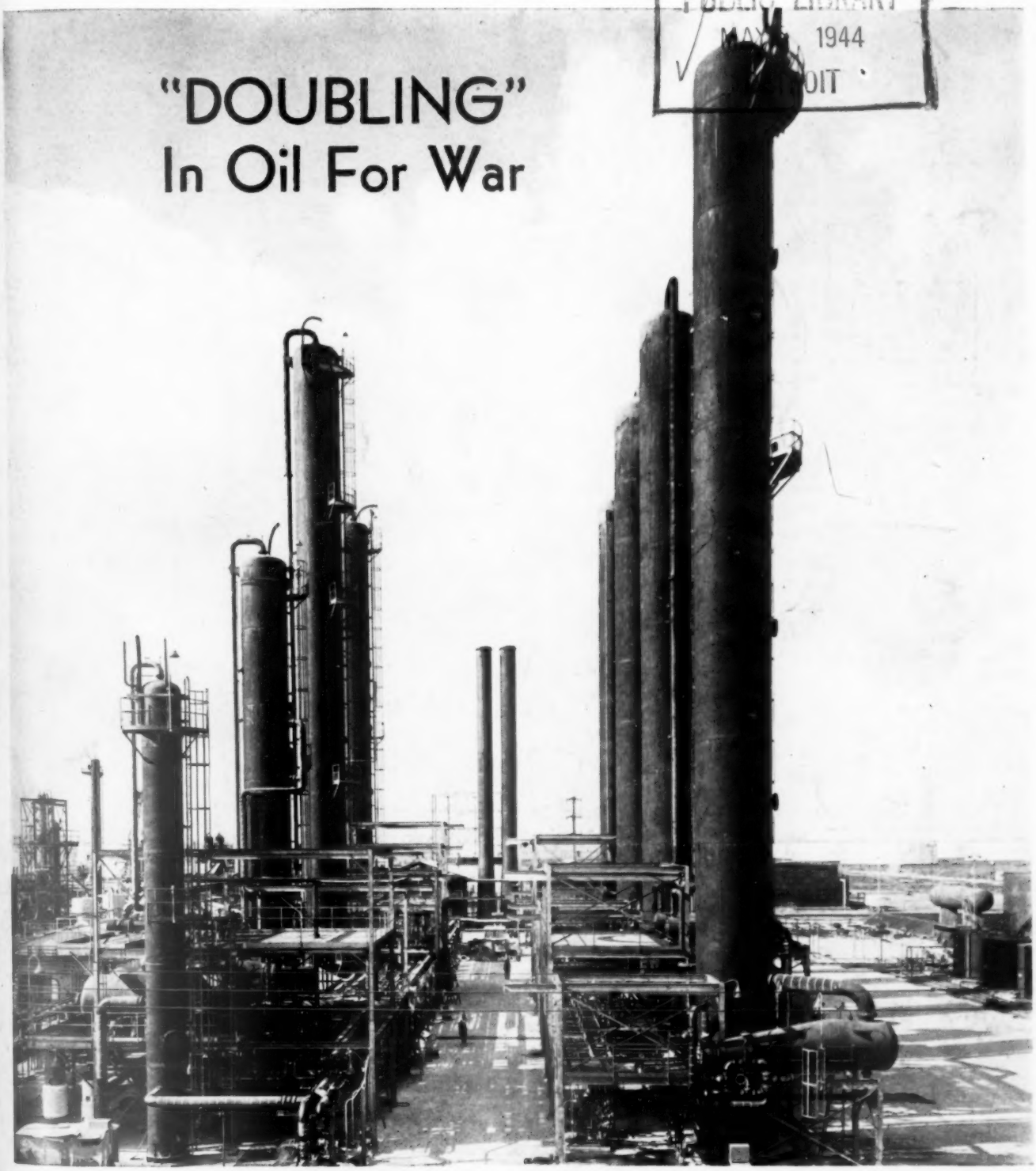
MAY 1944
DETROIT

"DOUBLING" In Oil For War



The toluene plants of the oil companies, built to make material for the manufacture of TNT explosive, have so fully met this wartime need that a substantial portion of the output of most plants has been diverted for use as a blending agent to improve the qualities of aviation gasoline. The processing of the toluene for this second wartime use is not changed except that the treating is less rigid since a nitration grade is not required. Typical of the wartime toluene plants is that of Shell Oil Co. Inc. at Dominguez, Cal. In the extractive process the toluene cut is distilled from an effluent from the refinery hydroforming unit; the toluene is solvent extracted from this cut, then fractionated from the solvent and washed and treated to the required stage of purity for blending in 100-octane gasoline

Receives Hanlon Award For Plant Design Economies

Meinhard H. Kotzebue . . .

EIGHTH recipient of the Hanlon honor award sponsored by the Natural Gasoline Assn. of America is Meinhard H. Kotzebue, president of the Gasoline Plant Construction Corp. In making the award April 13, at the association's annual meeting in Dallas, N.G.A.A. President James W. Vaiden said: "His foresight and practical engineering judgment in the design and construction of plants made possible savings in production costs and conservation of natural resources on a scale hitherto impossible by other means." Donor of the Hanlon award is E. I. Hanlon, Tulsa, pioneer in the natural gasoline industry.

Mr. Kotzebue, a native of Texas and an engineering graduate of Texas A. & M. College, was an officer flier in the first world war. After working several years in design engineering in Oklahoma, he moved to Houston in 1937 and organized his own company.

REFINERY MANAGEMENT *and*
PETROLEUM CHEMICAL TECHNOLOGY

May 3, 1944
Volume 36
Number 18

A MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS *incorporating International Petroleum Technology*

Shortage of Plant Maintenance Men Threatens Aviation Gasoline Output

SOME refinery managers are already running into difficulties in holding plant maintenance work to the schedules set up, due to the loss of men from the maintenance crews into the armed services. Moreover, they believe this condition may lead to increasing the downtime of refinery units this summer to the extent their output of aviation gasoline may be affected.

In anticipation of such a situation, some plants are now revising their downtime schedules to stagger this work to a greater degree and spread out more evenly the demands on the services of the maintenance crews. In asking for deferments for the men they feel they cannot replace, the companies are emphasizing to their local draft boards the importance of the maintenance and repair work in keeping the plants operating at highest efficiency.

The Refining Division of the Petroleum Administration for War has also recognized the condition brought about by the shortage of maintenance men. It has suggested in certain critical areas, the "pooling" of the maintenance men from several or all companies. Large-sized crews could thus be built up and sufficient numbers could be assigned to a plant when its units were down that the necessary inspections, cleanout and other maintenance could be done quickly to get the plant back on stream.

Big Units Coming Down

Coupled with even the present shortage of maintenance men is the fact that many of the units coming down over the next few months will be large installations using new processes. It will take more time for the crews to go over these units than is normally allowed for shutdown time, or larger crews.

Plant superintendents say that, on some of the new catalytic cracking units, it will take 200 or 300 men to go over them and finish the required maintenance work in two or three days. Units of this type will have to be shut down at least three or four times a year for routine maintenance work. Extending the time the unit is down will substantially affect the refinery's output of aviation gasoline, it is said.

On the large capacity combination crude distillation and catalytic cracking units of one company, records show it normally takes from 5 to 7 days of downtime for ordinary maintenance and repair on a regularly scheduled basis. Due to the present shortages of personnel, it now takes 18 to 21 days for the same work to be done.

The new type of processes, with their highly involved mechanical operations, automatic recording and control and so on, have greatly increased the maintenance requirements. Even before the war the time had passed when a relatively few men who were "jacks of all trades" could handle all the necessary repair and cleanout work when a unit was down. While fewer experienced operators are now required to run the units, the number of men needed for their maintenance has proportionately increased. The manager of a plant with 600 men said that maintenance operations required 50% of the technical manpower there.

Experienced workers from a number of highly skilled crafts must be included in the maintenance crew of the modern refinery. Among them are boiler makers, all-around machinists, brick masons, high-pressure vessel welders, electricians, and instrument repair men, all recognized as critical occupations by the War Manpower Commission. The non-critical occupations include carpenters, pipefitters, insulators, crane operators. Refinery operators say that it takes three to four years to train men in one craft for efficient plant maintenance work and that the most experienced in their craft are not fitted to substitute for a worker from another craft. These technicians have to have helpers to work efficiently and as provided by union rules and the helpers have to be trained.

Many Lost to Draft

Under the present status of the draft, the companies in most cases are holding the men in their maintenance crews in the critical occupations; but they are losing the workers in the non-critical group and also the helpers in both groups. The loss of sufficient workers in any group slows down the maintenance work. However, the managers anticipate their losses into the armed services will be proportionately higher if the draft age is extended to take in men from 26 to 30 years of age. Due to the length of training required, a good share of the men in the maintenance crews are in this age group.

In making their representations to the draft boards for the men they feel they cannot replace, the oil companies are pointing out the essential character of their work contributing to the output of aviation gasoline. They certify that these men are as important as the plant operators in maintaining high output.

Among the steps the oil companies are taking on their own initiative to avoid a labor bottleneck this summer because of the shortage of maintenance men are the following:

Companies operating more than one refinery are coordinating the downtime schedules of all the plants, so that all available men can be thrown onto a single unit when it is pulled down.

They are maintaining the regular downtime schedules even though some units have to come down for emergency repairs. In such cases they are making only the necessary repairs and postponing the metal inspection and other regular maintenance work on the unit until the scheduled time.

The trained and experienced men in the crews are being assigned where they can serve in more of a supervisory capacity and also aid in training other workers.

Several practical objections are seen to the proposal for pooling maintenance work for plants in a given area. Some refinery managers believe difficulties will be encountered through the fact the men belong to different unions, some to company unions and others to A. F. of L. and C.I.O. unions. Another objection cited is that all outside plants would be "new" units to the maintenance men and their work would be slowed down as compared with the time on the units in their own plant. It is also pointed out that the maintenance crews, as now organized in most plants, are busy on necessary work all the time and that to dispatch them to work in other refineries would disrupt a good deal of work in their home plant.

Some of the large refinery contracting firms are considering organizing crews and taking over the maintenance work for a group of plants in a given area, which would be done on a contract basis with the oil company. It is believed that difficulties with the unions might be thus avoided and the contractors think, since much of the work of constructing the wartime plants has been completed, they can find and train men capable of much of the routine maintenance work.

NPN Presents Exclusive Series on Process Engineering

Articles by Well-Known Authority in Petroleum Refining Field Will Deal with Improved Methods for Correlating and Predicting Fundamental Data Required for Design of Modern Refinery

IN RECENT YEARS there have been many improvements in methods of process analysis and design. Empirical formulas of restricted applicability have been replaced by fundamentally sound relationships which are valid for all types of substance over wide ranges of conditions. The results of these methods in many cases are limited in accuracy and reliability only by the accuracy of the fundamental physico-chemical data employed in their application.

For example, excellent fluid flow relationships are available for calculating pressure drops and sizing lines and valves under all types of process conditions. Similarly, heat transfer coefficients are accurately expressed by equations applicable to the design of heat exchangers, condensers, coolers and the like. However, the value of all this development is lost if inaccurate physico-chemical data are employed in these fundamental methods. An erroneous density or viscosity value may result in a control valve or pump just as inoperable as though the fundamental principles of fluid flow had never been studied.

Elaborate and reliable methods have been developed for calculating the number of theoretical plates required in distillation, absorption, and stripping. Yet errors in the relative volatilities or vaporization equilibrium constants used in these methods may lead to completely inoperable results. In this connection much confusion exists in the interpretation of the results of operating fractionating equipment in terms of plate efficiencies. The plate efficiencies calculated from a given set of operating data are to a large extent dependent upon the vaporization equilibrium constants employed. The fact that different investigators assign different values to these constants under identical conditions has seriously interfered with the development of useful generalizations relating plate efficiencies to factors of plate design and the physico-chemical properties of the fluids.

It seems to be the lot of the process engineer that in every new project there should be numerous physico-chemical properties for which no direct data are available and which must be estimated in one way or another in order that the design may move forward. Experimental determination of many of these properties requires precision technique and equipment not ordinarily available to the engineer and becomes all but impossible for unstable organic compounds, particularly at elevated temperatures and pressures.

Because of the widespread importance of this problem of missing data, the University of Wisconsin has for the past 18 months directed a portion of the graduate research program in chemical engineering toward the development of improved methods for correlating and predicting the more important fundamental data required by process engineers. This study was incidental to a research program chiefly concerned with catalysis and kinetics which was made possible through the support of the Wisconsin Alumni Research Foundation. The work on process engineering data will be reported in a series of original articles to appear each month in the Technical Section of NATIONAL PETROLEUM NEWS.

K. M. Watson, Ph. D., co-author of the series of articles on process engineering data, supervises petroleum research at the University of Wisconsin. At present Professor of Chemical Engineering at the University, he has had extensive experience since 1930 in the petroleum industry, with Gulf Oil Corp. and Universal Oil Products Co. He has also been associated in a technical capacity with many important war undertakings, including the Neches Butane Products Co.

The developments described in these articles are of particular interest to the petroleum industry because of the attention devoted to the properties of mixtures and solutions at high temperatures and pressures. However, for the most part the methods are general in nature and may be directly applied to many organic materials other than hydrocarbons. For this reason the original papers are written as a series of research reports in which fundamental methods are developed and their application to general process engineering problems discussed. At a later date it is hoped to present design charts which have been developed for the specific application of these methods to hydrocarbons and petroleum fractions.

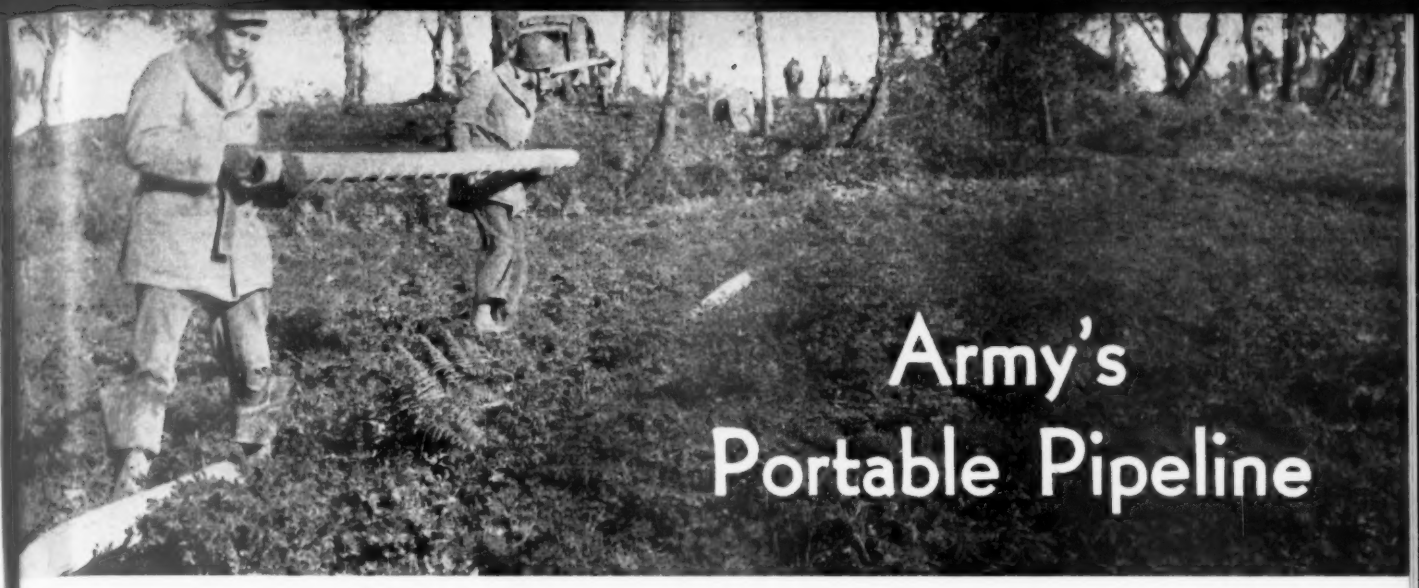
The first paper in the series, which appears in this issue, page R-258, is "Vapor Pressures and Critical Properties of Organic Compounds," by B. W. Gamson and K. M. Watson. In it are developed improved methods for estimating the vapor pressures and critical constants of a variety of organic compounds. The second article, to appear in the June 7 issue, presents a critical review of the thermal properties of the hydrocarbons and improved correlations which are thermodynamically consistent and based on the most recent data arrived at by spectroscopic and statistical methods.

The third article, to appear in the July 5 technical edition, presents a simple method for arriving at useful approximations to the heats of formation, absolute entropies, and heat capacities of organic compounds. By these methods it is possible to calculate heats of reaction and reaction equilibrium constants with no direct data other than the structural formulas of the compounds involved.

The next two articles will deal with the thermodynamics of solutions at high pressures.

In later articles a generalized correlation of viscosities in both the liquid and vapor phases will be presented, followed by the report of an experimental study of flow through granular beds. This later work is directed particularly at the pressure drop and distribution problems encountered in fixed catalyst beds and includes a study of the effects of methods of packing on the pressure drops observed with a variety of different particle shapes.

See Page R-258 for First Article—"Vapor Pressures and Critical Properties of Organic Compounds"



Army's Portable Pipeline

Signal Corps Photo

How Systems Are Laid Out, Pipe Strung, Pumping Stations Operated by Army Crews to Supply Gasoline to Troops as They Advance to Front Line Positions

THE U. S. Army's portable pipeline has had its trial by fire and is now in use on many battlefronts, transporting gasoline from advance supply bases to troops in the front lines. It is truly a "portable" line. All its parts have been designed so that it can be laid on the surface of the ground at the rate of up to 30 miles a day. The 4-in. line which is mostly used supplies as much as 4800 barrels a day of gasoline at pressures ranging from 200 to 600 pounds per square inch.

The 20-ft. joints of spirally welded pipe weigh approximately 100 pounds on the average and are easily carried by one man, who needs only a wrench to couple one joint to another by means of a flexible coupling. Regular troops can do the work, even under blackout conditions, without special training or equipment.

Pumping units are mounted on skids, complete with a complement of regulator, relief and control valves, and hauled into position by truck or tractor. The unique mechanical feature of the system is the throttling control valves by means of which the pressures in the line are used to control the rate of flow, through the automatic regulation of the speed of the engine operating the pump. Thus flow in line can be turned on and off at the delivery point just like a garden hose, without damage because of too great pressures, regardless of grade or length of the line.

The portable pipeline is the invention of Sydney S. Smith, New York, manager, Products Pipe Line Department, Shell Oil Co. Inc. It was originally devised to transport gasoline over the Burma Road and was first used by the U. S. Army in the North African campaign. Mr. Smith and Shell Oil Co. gave the patented design and operating rights to the U. S. Army without fee or license for the duration of the war, cooperating fully to improve its features as military experience dictated their necessity. Although announced in the summer of 1943 (*NPN Aug. 4, p. 6*), details concerning construction and operation have only recently been made public by the Army.

The pipeline is made up of standard units, each unit comprising a pump station and the required length of pipe to cover the distance to the next station. The line portion of these units is composed of four basic pipe sections and the combination of these sections in proper sequence permits the laying of the line over any type of terrain. These basic sections are as follows:

Pipe Section consisting of a straight 20-ft. joint of pipe.

Valve-Pipe Section consisting of a straight 20-ft. joint of pipe containing a Wheatley self-cleaning rack type gate valve.

Gate and Check Valve-Pipe Section consisting of a straight 20-ft. joint of pipe containing a Wheatley gate valve as above and a Wheatley self-cleaning rack type twin gate and check valve.

Regulator-Pipe Section consisting of a straight 20-ft. joint of pipe containing a Wheatley gate valve with a by-pass around it. Mounted in the by-pass is a Hanlon-Waters double port spring loaded Regulator with Wheatley gate valves on either side.

When the line is laid, block valves are placed every mile, or even closer at bad crossings, rivers, bad soil, and for other reasons. Sections of pipe containing twin gate and check valves are used as necessary on up-grades to provide suitable automatic protection against runback in case of breaks or leaks. They also prevent accumulation of pressure through stations, where automatic controls have functioned to by-pass the station. The regular sections are used on long down-grades in direction of flow to prevent dangerous pressure build-up when the line is closed and normal flow interrupted, where ground gradient exceeds safe hydraulic gradient, and where pressure reduction is desired in normal operations.

Pipe used in the line is the spiral weld type manufactured by the Naylor Pipe Co., and tubular pipe manufactured by Youngstown Sheet and Tube Company. Thickness of pipe is No. 14 Old U. S. Standard Gauge, 0.0781 in., outside diameter at ends 4.5 in., with ends grooved in accordance with specifications set up by the Victaulic Co. of America for use with their couplings. Each length is mill-tested to 900 psi and certified for normal working pressure of 450 psi, occasional pressure up to 650 psi, and under extraordinary load to maintain up to 800 psi without distortion. The steel must have approximately 53,000 lb. ultimate strength in tension, weigh about 4.2-4.8 lb. per ft., and is spiral fusion welded. Safe suspensible length with pipe full of 0.75 gravity gasoline, including weight of one coupling per joint, is approximately 650 ft. with safety factor of four.

It should be noted that while the description contained in this article refers specifically to a 4 in. line and its corresponding pumping equipment and controls, a similar design for a 6 in. line with related equipment has also been developed. The operating and control features of this larger line are identical to the 4 in. line discussed herein.

Pumping Engines

Pumping units, the heart of the pipeline stations, consist of a Model K-428 Buda 6-cylinder 4⅜ in. bore, 4¾ in. stroke, 428 cu. in. displacement gasoline engine weighing 1800 lb. and a Fig. 1860 gasoline, 4½ x 6 gear-driven, duplex

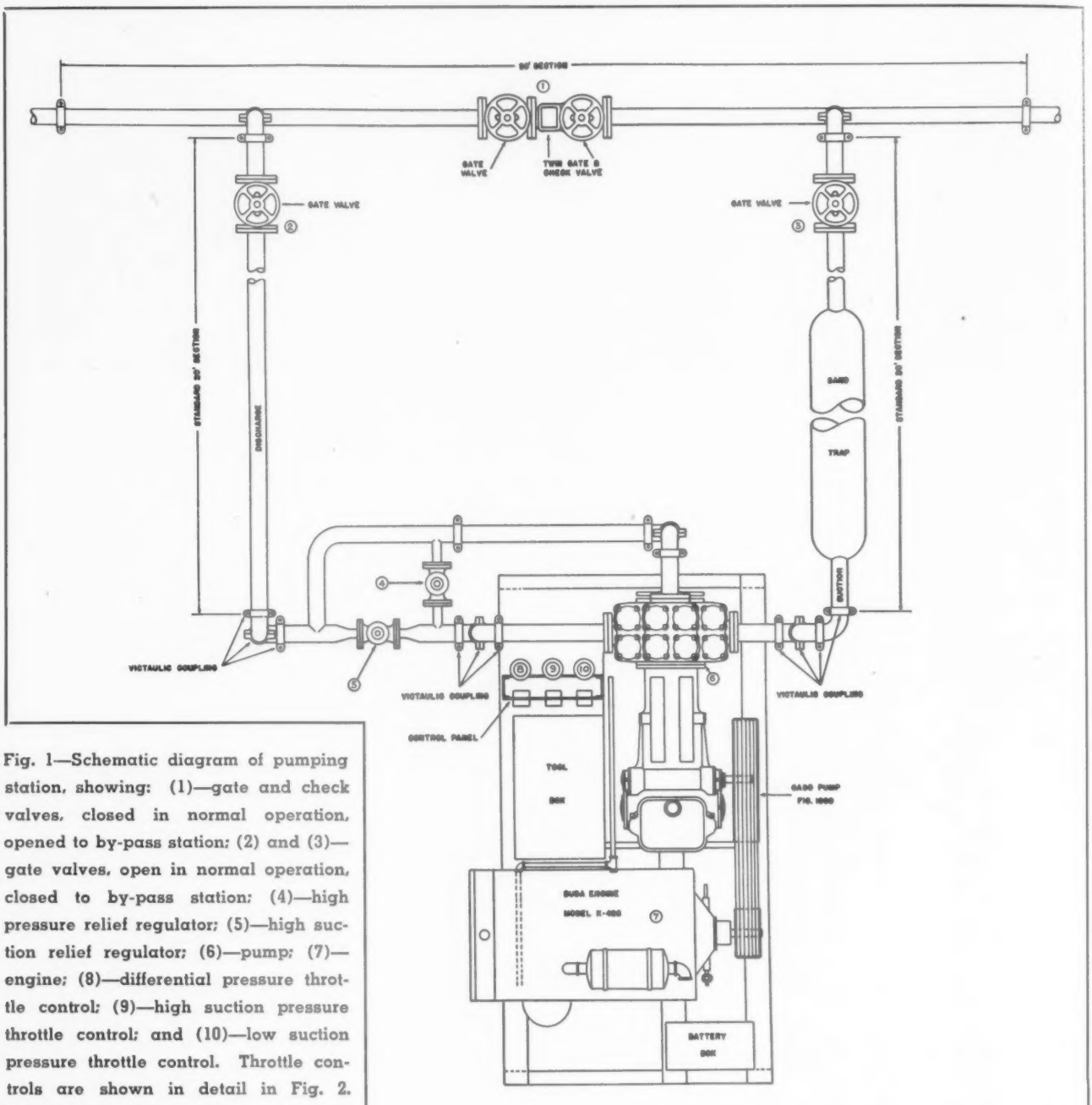
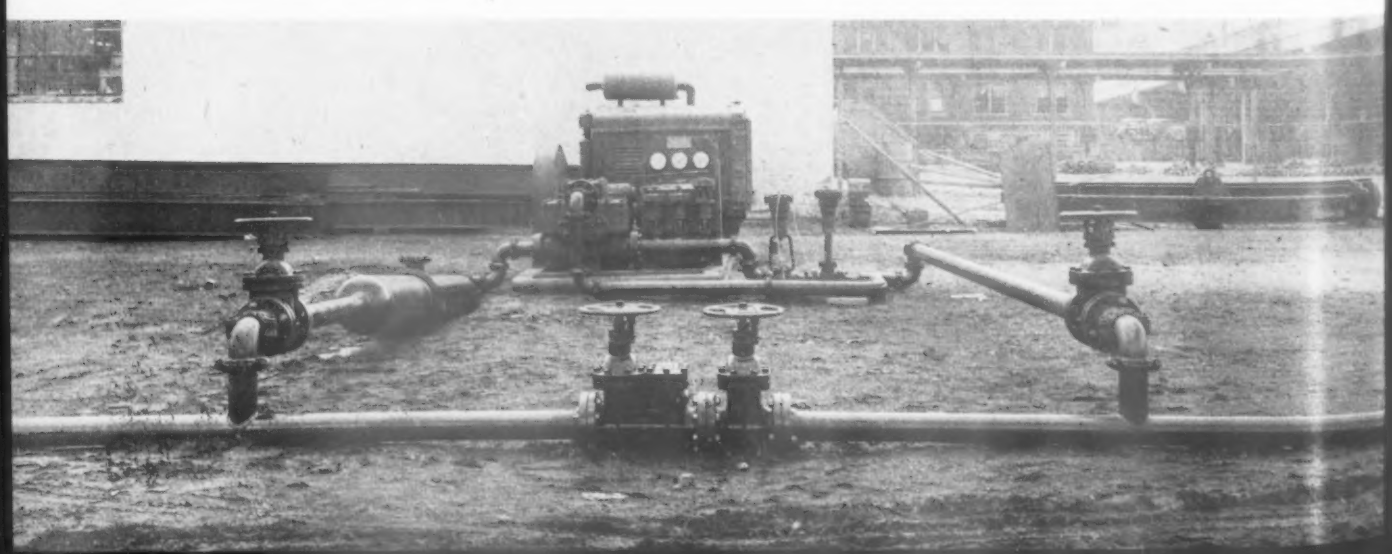


Fig. 1—Schematic diagram of pumping station, showing: (1)—gate and check valves, closed in normal operation, opened to by-pass station; (2) and (3)—gate valves, open in normal operation, closed to by-pass station; (4)—high pressure relief regulator; (5)—high suction relief regulator; (6)—pump; (7)—engine; (8)—differential pressure throttle control; (9)—high suction pressure throttle control; and (10)—low suction pressure throttle control. Throttle controls are shown in detail in Fig. 2. View below shows assembled pump station set up in yard of fabricator—Hanlon-Waters, Inc., Tulsa



double-acting reciprocating piston pump with power application from engine's V-belt, weighing 2000 lb. In normal operation this unit delivers 200 bbl per hour of gasoline with a differential pressure of 200 psi, requiring approximately 20 hp. The units are designed to maintain this rate even when one or two adjacent stations are out of service, the two or four upstream stations operating at 150% of normal pressure, or with a differential of 300 psi, and increasing the engine power required to 30 hp. Normal operating speed of the engines is 1000 rpm and the units are capable of developing 53 hp at this speed.

Thus it will be seen that conservative design has been practiced throughout, which is deemed desirable considering the conditions under which the unit may have to operate. Comparatively light loading and low speed also make for long life and trouble-free operation, a very happy combination—for military requirements especially.

Signal Corps Photo

Closeup (above) of throttle controls, by means of which line pressures are used automatically to regulate engine speeds and rate of flow

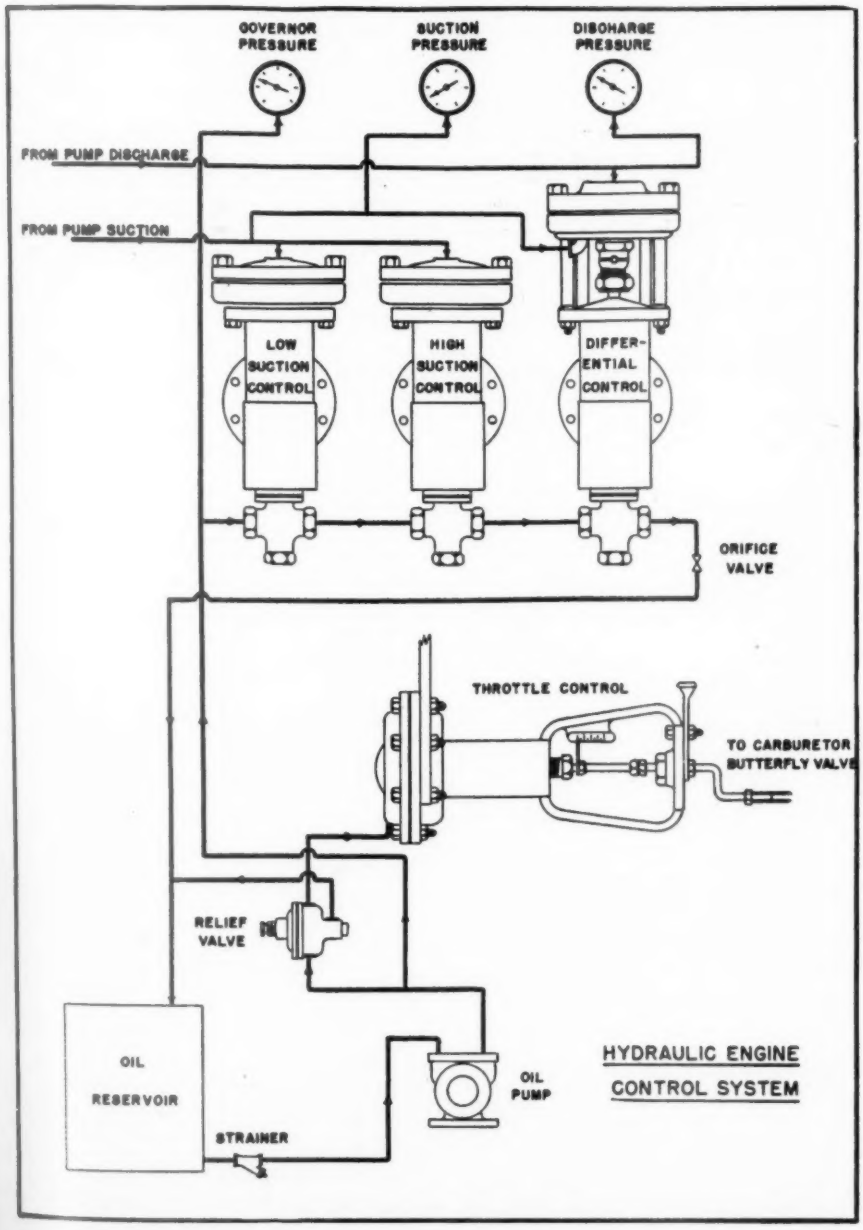


Fig. 2 (left)—Schematic diagram of engine control system

Station Controls

The system of controls, some of them long familiar in pipeline practice while others are unique, are especially combined to fit the needs of this particular application. Roughly, these may be grouped into pressure-relief valves and throttle-control valves.

A schematic diagram of a station installation is shown in Fig. 1. Point 1 is a unit-combination of two gate-valves with a check valve between them. Both gate valves normally would be closed with the station in operation and, if it became inoperative for some mechanical reason, they would be opened manually, and the check valve would permit downstream flow, only, by-passing the station. Points 2 and 3 are gate valves in discharge and suction lines, respectively; both are open in normal operation. Point 4 is a high pressure relief regulator, opening at 650 lb. with increasing discharge pressure; Point 5 is a high suction-pressure relief regulator, opening with increasing suction pressure ranging from 350 to 400 psi, setting depending on nature of terrain. Point 6 is the pump and Point 7 the engine.

Points 8, 9, and 10 (on the engine) are engine governor controls, throttling engine speed under conditions of high suction pressure, low suction pressure and differential pressure. The latter keeps the station instantly ready to operate when abnormal line conditions are relieved and serves to distribute the load between two closest stations when an in-

tervening station has been taken off the line for some reason.

Engine Governor Controls

The engine-governor controls, affecting the throttle, are a closed hydraulic system, as shown in Fig. 2. A small oil pump, designed to handle 1 gal. per minute of S.A.E. 10 lubricating oil at proper speed, is mounted on the engine and driven by the same shaft which operates the magneto. Oil is drawn from a small reservoir and discharged into a piping header connecting several diaphragm-operated throttling control valves. As the engine rotates, the pump circulates oil at a speed proportional to engine speed across a needle-valve with locking arrangement. As engine speed increases, pressure across the valve increases also, and the diaphragm to throttle closes the throttle when engine speed reaches a set value (usually 1000 rpm). The three other diaphragm valves in series with the pump discharge and needle-valve are independently and individually capable of further restricting the throttle adjustment.

The first throttling control, affected by differential pressure, is adjusted to operate when the differential pressure across the pump exceeds 300 psi. In operation, it throttles the engine in such manner that the station adds a maximum of 300 lb. pressure to the suction pressure, whatever the latter may be. At 650 lb. the high-pressure by-pass (see Fig. 1) opens, permitting discharged liquid from the pump to circulate back to the suction side of the pump; as a result, suction pressure tends to approach discharge pressure, but, at between 350-400 lb the second by-pass valve, called the high suction pressure relief, opens and equalizes discharge and suction pressures.

The operation of the unit under the differential controller is such that when a downstream unit is shut down, the controller, working off both suction and discharge lines of the station, tends to operate the unit to a maximum of about 150% of normal working pressure, or 300 lb differential between suction and discharge, serving to distribute the load from the shutdown unit through the two preceding upstream units. Or if two adjacent stations are inoperative, the load normally carried by these units is distributed to the four preceding stations, each of which operates with 300 lb pump differential.

The second diaphragm valve on the closed circuit oil system is set to operate at a pressure just above that of high suction pressure relief and is so adjusted that it will slow the engine to comfortable idling speed without the station doing work on the line, until suction pressures at the station again fall towards normal operating conditions.

The third diaphragm valve controls the station in normal operation. It is actuated solely by suction pressure and closes as suction pressure decreases. This prevents the pump "sucking the line dry". When suction pressure falls, the valve closes an amount sufficient to permit the pressure to be maintained at 10-20 psi. Thus, the pump operates always to return the same amount of liquid to the line as it receives.

Pump stations are generally placed 10 miles apart, but this distance is varied according to the terrain. A graphic solution ordinarily is used to permit quick location of proper points for stations and valves. Such a profile, exemplifying several types of terrain, is illustrated in Fig. 3 and discussed by Shell's engineers:

"The profile, which may be constructed from military maps, surveys, or even from aneroid readings compared against speedometer or pedometer readings, is used as the basis. Some standard scale is used and in Fig. 3 the scale is 8 miles to the inch, and 200 lb of hydrostatic pressure in gasoline of 0.73 specific gravity per inch was used as the vertical scale. (To construct such a scale, a 3.16 ft. column of gasoline equals 1 lb of pressure, or appropriate metric units may be used.)

"A flow rate of 200 bbl per hour was used as the basis of design for the line. This is equivalent to a pressure loss of 20 lbs per mile in 4 inch pipe, or 200 lbs for 10 miles. From these factors, the triangle illustrated in Fig. 4 is constructed showing pounds per sq in. vs miles, and these are used to plot the flow pressures along the gradient or profile. (This type of solution is elemental and well known to pipe line engineers—Ed.) Wherever the graphed line, as plotted by the appropriate triangle from station point and pressure, extends to meet the profile line, the next station should be located.

"The functioning of the stations under various types of operation is described later, but it is important to note several points. It is necessary to rather accurately lay out the spacing of the stations because the operations of the stations are a direct function of the pressures required by the line, which pressures in turn are determined by the length of the section and the terrain over which it is laid. Moreover, because of the pressure limitation of the pipe, namely 650 psi, and the fact that the station just upstream from the two inoperative stations, will be discharging at a pressure just below this amount, it is necessary to observe certain conditions which would obtain if the flow were interrupted downstream on a decreasing gradient.

"Stations should not be placed just at the top of a hill; an example of this is shown at Station 16, Mile 103. Here, if the pressure reducing station on the previous downgrade was

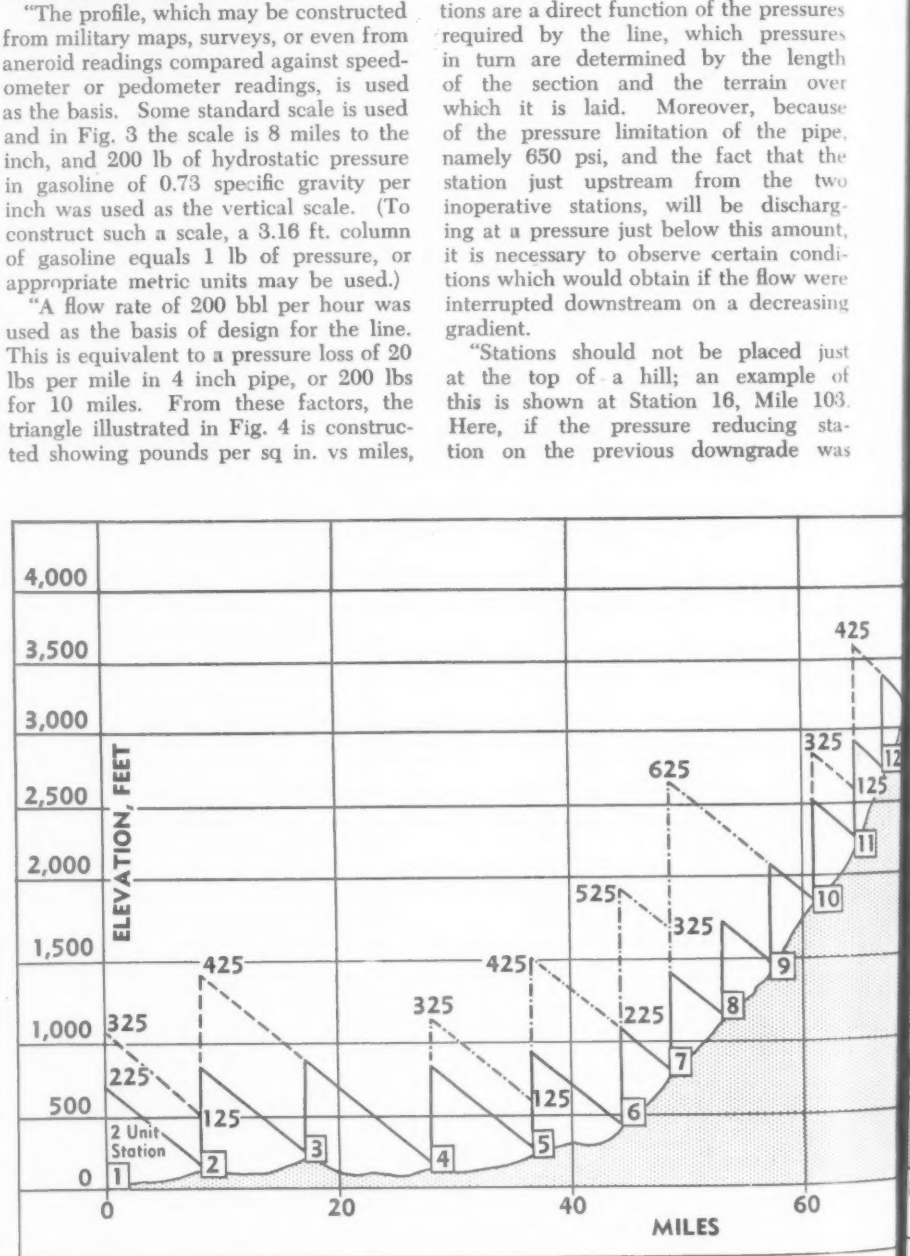


Fig. 3 illustrates the application of the modular system of hydraulic design to determine the location of pump stations and pressure reducing stations of an hypothetical pipeline. Detailed description of this application is given in text. Calculations are based on rate of 200 bbls. per hour, equivalent to friction loss of 20 lbs. per mile of 4 in. pipe. Design is based on station suction pressure of 25 lbs. and pump differential of 200 pounds. Solid line depicts pressure characteristics of system with all stations operating. Uniform broken line (-------) depicts operation with single station out of service. Thus, with stations 3 and 12 inoperative, stations 1 and 2, and 10 and

adjusted to permit a greater pressure carry-through to Station 13, it would be possible to move Stations 13, 14, 15, and 16 further up the hill, placing Station 16 at the brow of the hill at about Mile 105. In this instance if Station 16 was pumping through to Station 19, discharging at 625 psi, and if the line were to be shut off against the flow at Mile 135, the pressure would rise to over 800 psi at Mile 132 and would reach the safe allowable pressure of 650 lbs at about Mile 109. This would require a pressure reducing station at or before Mile 109. However, the pressure reduction could not be in excess of approximately 100 lbs, otherwise Station 16 could not pump through to Station 19; hence additional pressure reducing stations would be required to protect the pipe further along. With Station 16 below the brow of the hill a single reducing station at Mile 128 is the only requirement of the long downgrade from Mile 106. The same point is well illustrated at Mile 73 where any pressure above that required to just get over the hill will be wasted anyhow at the reducing station at Mile 81.

"In the same general manner the points may be determined at which pressure reducing stations may be requisite. Thus, at Mile 73 the suppositional pipeline descends a hill of such a height that closing the line at Mile 87 would create a hydrostatic pressure of about 1000 lb, sufficient to burst the pipe. This can be prevented with the pressure reducing station as shown at Mile 81. The suggestion is offered that more reducing stations be used than are needed, because the more valves installed, the less likelihood there is of failure and the less repairs will be required by each valve as a result of each one doing less work.

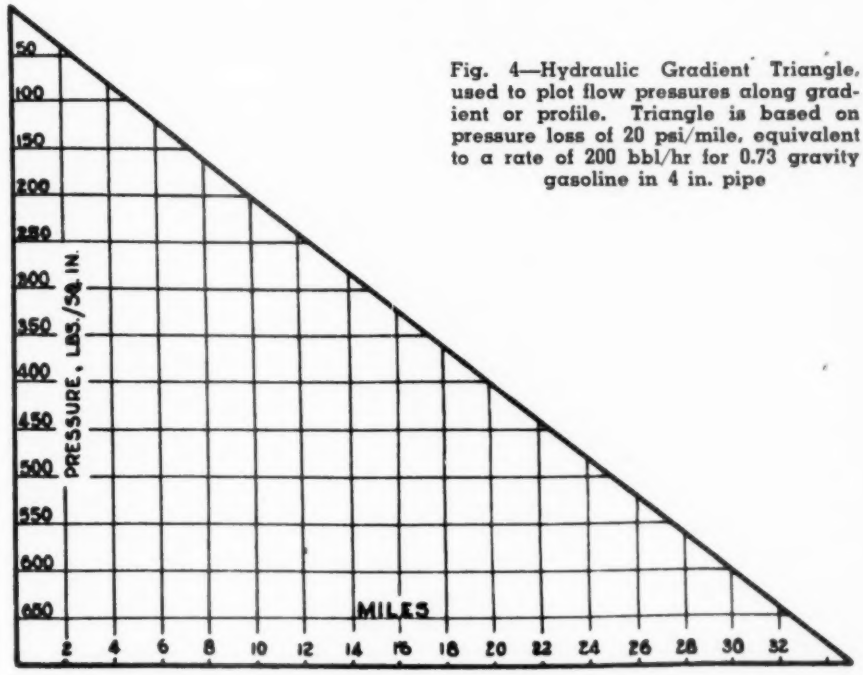
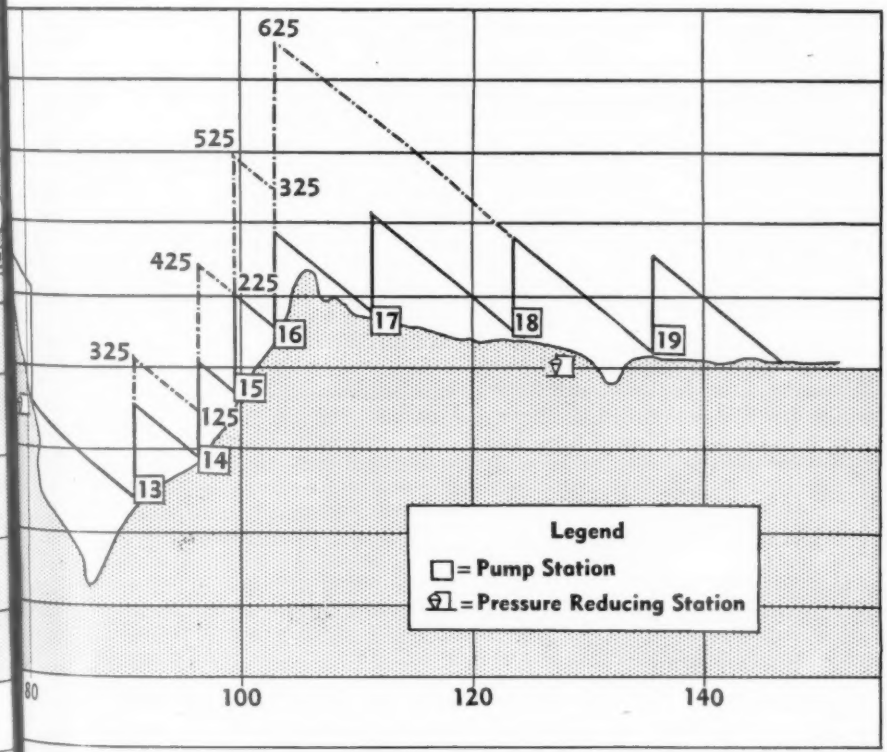


Fig. 4—Hydraulic Gradient Triangle, used to plot flow pressures along gradient or profile. Triangle is based on pressure loss of 20 psi/mile, equivalent to a rate of 200 bbl/hr for 0.73 gravity gasoline in 4 in. pipe



will each assume 50% of load normally carried by 3 and 12, each operating with pump differential of 300 lbs. Broken dotted line (————) depicts operation with o adjacent stations out of service. Thus with stations 8 and 9, and 17 and 18 inerative, four stations upstream from each group of shutdown units will each assume % of the load normally carried by the units 8 and 9, and 17 and 18, each operating ith 300 lbs pump differential. This condition causes stations immediately upstream, this instance 7 and 16, to operate with a discharge pressure of 625 lbs, maximum safe working pressure of the pipe

"The location of the second station and the setting of the high pressure throttle on the first station provides the rate control on the line. They should be located together so as to provide a 200 bbl per hour pumping rate and nominal load on the engines of the No. 1 station, which must be kept running at all times. Since part of the function of the first station is to fix the maximum rate of pumping, it is advisable also to provide a two-unit station at the second station, then the rate is fixed by the pressure drop across the first section of line. Alternately the controls may be changed on first station, but this is less desirable.

"After the line is in operation, slight adjustments may be made to compensate for minor errors in the location of stations. This is very easy of accomplishment since any station can be moved to any other point at any time."

Special Construction Features

Two points of care during construction are recommended by the designer:

"Minor errors in design pressures cause no difficulty provided that due care is exercised in the placing of stations on steep upgrades so that the suction pressure created at each station by the previous station is sufficient to operate the high suction relief valve and high suction throttle. If it is not, the station control will be incomplete, for obvious reasons. The other point of care is that the

reducing stations be located so that minimum energy is lost when the line is operating."

Given sufficient truck and stringing force, there is no difficulty laying line and having stations operating at up to 30 miles a day. Operation of the units being largely automatic, no pipeline-trained personnel is required at the station, and regular military personnel can do all the installing required. A standard 20-ft joint, suitably equipped with pressure-reducers and nipples for attachment of hoses, could be the terminus of the line from which tanks of vehicles could be directly filled. Suitably camouflaged tanks could also be used, to prevent need for continuous operation of the line at low discharge rates.

In actual military operation it is logical to conclude that a reversal of the pipe line would not be difficult if exigencies of the situation required a withdrawal of forces and return of stored gasoline to the original beachhead. Given sufficient time, and if water were available, even the line itself could be cleared of product and all equipment salvaged.

The design of the whole system is based on the idea that pressures in a pipeline can be used to control functionally flow in the line so that it can be turned on and off at the delivery point just like a garden hose. This is regardless of how level or unlevel, how long or how short the line may be.

As long as normal operation continues, each station handles just the amount it receives and does it in one of two ways: (1) If upstream stations all are running then the individual station will operate at 200 lb differential pressure and the engine will throttle to the appropriate speed to handle fluid at the pressure. (2) If some of the stations are not running then the preceding upstream stations will assume part of the load of the inoperative units (not exceeding 2 adjacent units), pumping at 150% of normal working pressure.

For purposes of description, reference is made to Fig. 3 which illustrates the hypothetical operation of a line composed of 19 stations. Addition of more stations and line sections adds no more complications but neglects intermediate withdrawals. Intermediate withdrawals may be eliminated from further consideration at once since they actually simplify operations, functioning to reduce line pressures. Shell's engineers describe operating combinations as follows:

Case 1 assumes all stations operating. The first station operates at 225 lb discharge, and each succeeding station operates on its low suction control, with a suction pressure of about 25 lbs, the line resistance downstream at 200 bbl an hour providing a discharge pressure of 225 lb. (In an intermediate withdrawal, downstream flow resistance-discharge pressure would drop; the engine then would run on the governor instead of throttling to suction, thereby limiting engine speed to permit pumping 200 bbl an hour maximum).

Case 2 assumes Stations 1 and 2 are operating continuously and Station 3 shutdown. Station 1 operates at 325 lb discharge; Station 2 with 425 lb discharge and its suction comes up to 125 lb, each functioning on its differential control to limit the load to 150% of normal, thus distributing Station 3's load to Stations 1 and 2. If all the remaining stations were operating, the pressure characteristics of the line from Station 4 to the terminus would be as represented by the solid line. For purposes of illustration, Station 12 is also shown out of service, with its load being carried by Stations 10 and 11.

Case 3 assumes Stations 8 and 9 to be down. These two stations would normally provide the 400 lbs pressure required to move product at 200 bbl per hour through the line from Mile 53 to 62. This 400 lbs is now distributed equally between Stations 4, 5, 6, and 7, each operating with 300 lb pump differential. Note that the suction pressures of 5, 6, and 7 are respectively 125, 225, and 325 lbs and the discharge pressures 425, 525, and 625 lbs. The same condition is illustrated with respect to Stations 17 and 18, with the load distributed to Stations 13, 14, 15, and 16 in like manner.

The last possibility, Case 4 (not shown in Fig. 3) assumes a valve closed somewhere in the line, as it might be if: (1) enemy action ruptured the line, necessitating throwing a loop around the damaged area; (2) flow is following laying of the line; or (3) terminal point tanks are full. On this instance the discharge pressure of the stations upstream from the blocked valve would gradually increase and if no relief were provided sufficient pressure could be realized to rupture the pipe and damage the pumps. In order to prevent pump pressure from exceeding a set limit, a high discharge relief is employed (see Fig. 1), adjusted to open at approximately 650 lbs, discharging to the pump suction. This relieving action places a heavy load on the pump; however, the high suction relief opens when the suction pressure reaches 350 lbs and the high suction control on the engine immediately throttles the engine to idling speed. Stations downstream from the blocked valve are likewise reduced to idling speed by action of the low suction control.

As soon as the block is cleared, high-pressure upstream passes to downstream side of the formerly blocked gate, raising suction pressure of the next downstream station. It immediately resumes pumping. This lowers the pressure at the adjacent upstream station as the flow commences across the opened block valve until the upstream suction pressure, bleeding through the by-pass check, is low enough to open the high-suction pressure throttle control and close the high-suction pressure by-pass. Thereupon station resumes normal operation. The consecutive reduction of pressure at each upstream station has a similar effect and permits swift return to normalcy.

View below shows 10,000 bbl. reserve tank "somewhere in Italy" which furnishes pumping stations with gasoline. At terminus of line gasoline can be pumped directly into tanks of vehicles or suitable camouflaged tanks

Signal Corps Photo

Manufacturer Receives Army Award For Record in Assembling Pipeline Units

Hanlon - Waters, Inc., Tulsa, was awarded the Army-Navy "E" in January for outstanding production in assembling pumping stations for the Army's portable pipeline.

Last November, with only ten days of the month remaining, the company found itself far behind its quota because of previous shortages of engines. With a supply of engines finally assured, the workers agreed to two 14-hour overlapping shifts and the plant went on a "28-hour day"—meeting the November quota 100%.

In the picture to the right, Sydney S. Smith (left), designer of the system, congratulates C. L. Hill, tool crib foreman, and Bus Tayrien, processing dept. foreman, both with Hanlon-Waters. Below—company president M. F. Waters (left) and Bert Sims (right), company employe, hold the award flag, with Col. H. A. Montgomery standing behind it.

Designer Credits Equipment Suppliers, Army Engineers for Pipeline Achievement

Enthusiastic cooperation and assistance from equipment suppliers and Army engineers helped make the Army's portable pipeline a success, according to Sydney S. Smith, designer of the system. In developing the special equipment required, assembling units, and working out other features of the military pipeline he depended heavily upon their help.

An acknowledgment from Mr. Smith of the contribution of these agencies is contained in his letter to the editors of NPN's Technical Section, after reviewing the article describing the line. He wrote as follows:

"The article you have prepared on the portable pipeline is factually correct, but I feel that it does not give sufficient credit to other people who have assisted in development of the whole project.

"Hanlon-Waters, Inc., Tulsa, were the prime contractors and were responsible for proper assembly and packing of all material. They built all control equipment and assembled all units. Theirs was the actual job of implementing the whole program.

"It should also be noted that all control equipment recommended to the Army and subsequently used was equipment already in current manufacture. This refers particularly to Victaulic joints, Naylor pipe, gate valves and check valves supplied by Wheatley Co., Gaso pumps, and Buda engines.

"This whole job is a tribute to the way American manufacturers cooperate, and to the understanding and ability of Army engineers who could visualize these units in operation. They were willing to take a chance early in the game that the whole project was workable and to purchase it in sufficient quantity to prove their judgment."

Vapor Pressures and Critical Properties Of Organic Compounds (Article 1 in a Series)

By B. W. Gamson* and K. M. Watson*

Abstract

Two forms of vapor pressure equations are developed, one satisfactory for the range from 0.1 mm of Hg to above the critical point and the other from 0 - 100 mm of Hg. These equations are applicable to all types of materials with errors generally less than 2% at pressures above 1 mm. For homologous series of organic compounds generalizations are developed for the prediction of critical properties, liquid densities, and the constants of the vapor pressure equations. For a member of the 15 series of compounds investigated these generalizations permit estimation of a complete vapor pressure curve from a single experimental value such as the boiling point.

FOR problems of vaporization and vapor-liquid equilibria, it is frequently desirable that vapor pressures be known with considerable accuracy and be expressed by mathematical equations valid over wide ranges of conditions. Accurate vapor pressures in the low pressure range are of particular importance in the thermodynamic relationships between entropies in the liquid and gaseous states. Fundamentally sound equations such as that of Clapeyron involve other physical properties which are not generally known and are difficult to evaluate. If these other properties are expressed through generalizations, the resulting combination of expressions becomes too complicated for engineering use.

Many empirical vapor pressure equations and correlations have been proposed. In general, those equations which are simple and convenient to use are of limited accuracy and applicable over only narrow ranges of conditions. The more rigorous empirical equations contain many constants which must be evaluated from extensive measurements on each material under consideration.

Extensive use has been made of linear reference substance vapor pressure plots of the equal pressure type proposed by Duhring[7] and the equal temperature type of Cox.[4] The latter plot is especially convenient and, as pointed out by Calingaert and Davis[2], results in lines which for an homologous series tend to converge at a single point. These investigators also proposed a convenient vapor pressure equation based on the Cox chart. However, the reference substance method of plotting is accurate only when a reference substance is employed which is closely similar in properties to the material in question. This greatly restricts its usefulness and a general Cox chart such as that of Calingaert and Davis, in which many substances are plotted against a single reference substance, is merely an approximation which in many cases leads to serious errors.

An improved reference substance plot based upon equal reduced temperatures was originated by Gordon[3] which is convenient and reliable for estimating heats of vaporization over wide ranges of conditions. The linear reduced reference substance plots of Gordon are of higher order of accuracy than the Cox chart but still leave much to be desired when applied over a wide range of conditions to substances dissimilar from the reference. They implicitly assume that the reduced vapor pressure curves of all substances may be superimposed, whereas this is not true even for members of an homologous series such as the paraffins. For example, if iso-pentane is used as the reference, this method results in a concave upward curve for ethane and a concave downward curve for octane. The slope of the ethane curve changes from 0.955 in the region of $p_r=0.8$ to 0.869 in the region of $p_r=0.01$. At the same points the slope of the octane curve varies from 1.13 to 1.19 respectively.

The present investigation was undertaken in an effort to develop a method of plotting, or preferably an equation, which is more accurate over wide ranges of conditions and which can be used as a basis for an improved generalized correlation of the vapor pressures of homologs such as was developed by Calingaert and Davis on the basis of the Cox chart. Additional methods for predicting critical properties were also studied because of the importance of these properties in practically all generalized correlations of physical data.

Vapor Pressure Equation (High Range)

Large scale plots of the logarithms of vapor pressure as ordinates against the reciprocals of reduced temperatures disclose that such curves closely approximate straight lines as the critical temperature is approached. At lower temperatures the actual curves deviate from the extrapolation of this linear portion and become concave downward. The length of the linear portion of the curve diminishes and the degree of curvature increases with increase in molecular weight in an homologous series. For example, the plot for ethane is almost perfectly linear down to a reduced temperature of 0.55 while that of octane begins to deviate where T_r is 0.70.

After investigating many forms of equations the following was selected as most closely approximating the requirements of combined simplicity and accuracy for the range of vapor pressures above 0.1 mm of Hg.

$$\log p = -\frac{A}{T_r} + B - e^{-20(T_r-b)^2} \quad \ldots\ldots\ldots\ldots (1)$$

where A, B and b are constants characteristic of the substance. A complete table of nomenclature appears at the end of the paper.

Equation (1) applied to the critical point gives

$$\log p_c = B - A - e^{-20(1-b)^2} \quad \ldots\ldots\ldots\ldots (2)$$

Since the exponential correction term is found to be negligible at reduced temperatures above 0.8, $B=\log p_c+A$ and Equation (1) may be written as

$$\log p_r = -\frac{A(1-T_r)}{T_r} - e^{-20(T_r-b)^2} \quad \ldots\ldots\ldots\ldots (3)$$

An advantage of the form of Equation (1) is that it extrapolates as a simple relationship above the critical temperature for the evaluation of vaporization equilibrium constants for the low-boiling components of mixtures.

Analytical evaluation of the three constants of Equation (1) is difficult and is best carried out by a semi-graphical method. The vapor pressure data are plotted, as previously described, with vapor pressures on a logarithmic scale as ordinates and reciprocals of reduced temperature on a linear scale of abscissas. The linear portion of this curve near the critical point is then extrapolated to low temperatures. Since the exponential term of the equation is negligible at high reduced temperatures the slope of this line is the constant A and the constant B is equal to $\log p_c+A$. The constant b is then evaluated from a single vapor pressure value at a low temperature where the actual vapor pressure curve differs significantly from the linear extrapolation of the high temperature portion. This difference

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is equal to the term $e^{-20(T_r-b)^2}$ from which b is readily calculated.

It is evident that this form of equation by itself is not convenient for the interpolation or rationalization of fragmentary vapor pressure data and it is not recommended for this purpose. However, if the constant b can be predicted by a generalized method the other two constants may be evaluated readily from any two vapor pressure measurement such as the boiling and critical points. Since methods are already available for estimating critical constants, these methods in conjunction with a generalized method of predicting b permit estimation of a complete vapor pressure curve from a single experimental value. It will be noted that the exponential term involving b is a correction which becomes important only at low temperatures. For this reason high accuracy in the evaluation of b is ordinarily not necessary for applications at temperatures near the normal boiling point or above.

The constants of Equation (1) were evaluated for over 40 compounds, comprising representative members of 15 organic series and a few miscellaneous inorganic substances. The deviations from experimental data were generally less than 2% for pressures varying from the critical down to 0.1 mm of Hg. Table I indicates the range of the constants encountered for some typical materials. Table II is a comparison of the vapor pressures calculated from Equation (1) with the experimentally determined values [8] for a few typical members of different homologous series.

Vapor Pressures of the Paraffins

Since more data are available for the paraffin hydrocarbons than for any other series, these compounds are selected as a reference to which the properties of other homologous series may be related. In Table III are listed physical properties of the normal paraffins containing up to 45 carbon atoms. The constants b, A, and B of Equation (1) are in Columns 9-11 and the corresponding boiling points and critical properties in Columns 4-6. For the lower members of the series these values represent merely a critical review of the available data with consideration of the continuity of the variations from one compound to another. The highest boiling paraffin on which complete vapor pressure data are available is dodecane which was studied by Beale and Docksey.[1] These investigators also determined the initial boiling points of several lubricating oil fractions over wide ranges of pressure. Interpretation of these latter data is made somewhat difficult by the significant widths of boiling range of the fractions and the accompanying influence on the slope of the vapor-pressure-temperature relationship.

TABLE I—Vapor Pressure Constants

	p_c—mm Hg	T_c—°K°	$\log_{10}p$ in mm of Hg A	B	b
Methane	34,810	190.7	2.3383	6.8800	0.000
Ethane	37,090	305.5	2.5728	7.1411	0.088
Ethylene	38,080	282.8	2.5463	7.1269	0.098
Propane	33,210	370.0	2.6606	7.1819	0.125
n. octane	18,700	569.4	3.2316	7.5034	0.236
Water	165,470	647.2	3.1423	8.3610	0.163
Methyl alcohol	59,790	513.2	3.5876	8.3642	0.243
di ethyl ether	27,000	467.0	2.9726	7.4039	0.204
Acetone	35,720	508.2	3.0644	7.6173	0.180
Ammonia	85,350	406.1	2.9207	7.8519	0.163
Methyl amine	55,940	430.1	2.9589	7.7066	0.239
Hydrogen cyanide	37,300	456.7	3.2044	7.7761	0.000
Methyl chloride	50,010	416.4	2.7195	7.4185	0.052
Carbon tetrachloride	34,200	556.3	2.7989	7.3329	0.158
Acetic acid	43,480	594.8	3.3908	8.0291	0.138

°0°C = 273.2° K.

TABLE II—Comparison of Calculated and Experimental Vapor Pressures in mm of Hg

Octane			Chlorobenzene		
Temp—°K	Calc.	Obs.	Temp.—°K	Calc.	Obs.
563.2	17,230	17,150	632.4	33,900	33,900
543.2	13,060	12,980	533.2	9,690	9,650
523.2	9,696	9,600	493.2	5,070	5,055
503.2	7,020	6,950	413.2	931	939.5
473.2	4,110	4,100	353.2	145.3	144.8
423.2	1,411	1,425	313.2	25.9	26.0
383.2	478	482	293.2	8.83	8.76
343.2	118.6	117.9	273.2	2.53	2.52
323.2	50.1	49.4	.....	.....	.....
293.2	10.38	10.45	.....	.....	.....
263.2	1.41	1.39	.....	.....	.....
238.2	.18	.17	.....	.....	.....

Acetone			di ethyl ether		
Temp—°K	Calc.	Obs.	Temp.—°K	Calc.	Obs.
508.2	35,720	35,720	467.0	27,000	27,000
493.2	28,830	28,960	453.2	21,910	21,900
473.2	21,200	21,280	413.2	11,070	11,080
433.2	10,530	10.560	373.2	4,822	4,859
373.2	2,770	2,790	333.2	1,707	1,729
313.2	419.5	421.5	293.2	438.2	442.2
278.2	89.5	89.1	243.2	36.4	37.6
243.2	11.2	11.2	213.2	4.11	4.10
223.2	2.39	2.40	193.2	0.6	0.6
203.2	0.37	0.34	.....	...	...

TABLE III—Physical Properties of Normal Paraffins

1	2	3	4	5	6	7	8	9	10	11
Carbon Atoms	Name	Mol. wgt.	T_B°R	T_C°R	p_C (lb) /sq in	ρ_l/ω_l g/cc	$v_c\omega_c$ (cc) /(g-mole)	b	A	B (lb) /sq in
1	Methane	16.04	201.2	343	673	3.679	4.36	.000	2.338	5.166
2	Ethane	30.07	331.8	550	717	4.416	6.81	.088	2.573	5.428
3	Propane	44.09	416.2	666	642	4.803	9.18	.125	2.661	5.468
4	Butane	58.12	491.1	766	544	5.002	11.62	.166	2.767	5.502
5	Pentane	72.15	557	847	482	5.128	14.07	.190	2.887	5.570
6	Hexane	86.17	615.7	915	433	5.216	16.52	.209	2.994	5.631
7	Heptane	100.20	669	973	396	5.290	18.94	.224	3.124	5.719
8	Octane	114.22	718	1,025	362	5.340	21.39	.236	3.232	5.790
9	Nonane	128.25	763	1,073	332	5.382	23.83	.248	3.298	5.819
10	Decane	142.28	805	1,115	312	5.414	26.28	.258	3.407	5.896
12	Dodecane	170.32	881	1,185	272	5.459	31.20	.275	3.637	6.071
14	Tetradecane	198.38	948	1,248	244	5.483	36.18	.289	3.818	6.205
16	Hexadecane	226.43	1,007	1,300	221	°5.48	°41.3	.300	4.006	6.350
18	Octadecane	254.48	1,060	1,345	202	°5.49	°46.3	.308	4.195	6.500
20	Eicosane	282.54	1,105	1,380	187	°5.5	°51.	.315	4.403	6.675
25	Pentacosane	352.67	1,210	1,465	156	°5.5	°64.	.329	4.834	7.027
30	Triacontane	422.80	1,305	1,545	133	°5.5	°76.	.339	5.169	7.293
35	Pentatriacontane	492.93	1,385	1,610	120	°5.5	°88.	.347	5.580	7.660
40	Tetracontane	563.06	1,465	1,675	108	°5.5	°103.	.353	6.011	8.045
45	Pentatetracontane	633.19	1,540	1,740	100	°5.4	°118.	.358	6.358	8.358

°Based on experimental density questionable because near melting point.

Reliable measurements of the critical temperatures and pressures of high-boiling petroleum fractions were made by Roess[10] in a continuous flow apparatus. These and other data were used as the basis of general correlations of critical temperature and pressure by Smith and Watson[11][12] from which the critical properties of Table III were calculated. The vapor pressure constants of the high-boiling paraffins were then arrived at by extrapolation of the constant b as a function of number of carbon atoms, in Fig. 1, with consideration of the vapor pressure data of Beale and Docksey on high boiling fractions. The constants A and B were then evaluated from the estimated critical properties and the boiling points listed by Doss[5]. Since some of these data are obviously inconsistent with each other, the values reported in Table III are smoothed average results obtained by plotting the properties against num-

ber of carbon atoms.

The resulting vapor pressure equations are in close agreement with the experimental data on the paraffins up to octane. For the higher paraffins the rate of increase of vapor pressure with temperature is somewhat less than that reported by Beale and Docksey for dodecane but greater than they found for the higher-boiling lubricating oil fractions. In general the results of the equations are intermediate between the graphical extrapolations recommended by Docksey and Beale[1] and by Coats and Brown[3].

The boiling points and critical temperatures of the paraffins and other organic compounds vary considerably with isomerization. Although there is indicated a small corresponding variation in the vapor pressure constant b the effects of these variations are probably within the errors of the method. Similarly, the critical pressure is little affected by isomerization. This is evidenced by the following values reported in atmospheres by Doss[3] for various isomers:

n. Butane	**37.47**	**Isobutane 36.9**
n. pentane	**33.0**	**isopentane 32.9; neopentane 33.0**
n. hexane	**29.5**	**3 methylpentane 31.9; neohexane 30.0**

For the series of compounds investigated it appears that the variations in critical pressure with isomerization are almost within the probable errors of the measurements and may be neglected as a working approximation. Accordingly, it may be assumed that the values of b and p_c in Table III and Fig. 1 are also applicable to the isomeric paraffins. Complete vapor pressure equations may then be derived from knowledge of the boiling points and critical temperatures.

Liquid Densities of the Paraffins

It was developed by Watson[13] that the densities of all liquids investigated are satisfactorily related to temperature and pressure by the following equations

$$\rho = (\rho_1/\omega_1)\omega \quad \ldots\ldots (4)$$

or $$v = (v_1\omega_1)/\omega \quad \ldots\ldots (5)$$

where ρ = density at temperature T and pressure p

v = molal volume at temperature T and pressure p

ω = "expansion factor" at temperature T and pressure p

(ρ_1/ω_1) and $(v_1\omega_1)$ = constants, characteristic of the substance under consideration and determined from a single value of ρ_1 or v_1 and the corresponding value of ω_1 at some temperature T_1 and pressure p_1.

The expansion factor ω is expressed graphically as a function of reduced temperature and reduced pressure which is substantially the same for all substances at conditions not too close to the melting point. The accuracy of this application of the theorem of corresponding states is considerably higher than similar applications to the gaseous phase and deviations from Equations (4) or (5) are generally less than 5% over wide ranges of conditions, up to and including the critical point. At reduced temperatures below 0.65 and at pressures not exceeding 10 atmospheres the expansion factor is satisfactorily expressed by the following equation:

$$\omega = 0.1745 - 0.0838\ T_r \quad \ldots\ldots (6)$$

Liquid densities at moderate temperatures are readily calculated from Equations (4), (5) and (6) if one experimental value is available to establish (ρ_1/ω_1) or $(v_1\omega_1)$ and the critical temperature is known or estimated. At high temperatures and pressures the general ω chart[13] must be used instead of Equation (6).

In columns (7) and (8) of Table III are values of (ρ_1/ω_1) and $(v_1\omega_1)$ for the paraffins, calculated for the most part from the densities of Doss[5]. The values for methane are based on the critical density because of the uncertainty of the densities reported near the normal boiling point. It will be noted that the values of $(v_1\omega_1)$ increase linearly with the number of carbon atoms while (ρ_1/ω_1) tends to approach a constant value. The density data up to tetradecane are satisfactorily represented by the following equation

$$(v_1\omega_1) = 1.88 + 2.44\ n_c \quad \ldots\ldots (7)$$

where

n_c = number of carbon atoms

For higher molecular weight compounds the reported densities are always lower than calculated by Equation (7) and tend to be erratic and inconsistent with each other. Since the validity of Equation (6) has been verified from data on other series of low-melting materials down to $T_r = 0.3$, it is believed that these deviations result from the fact that the measurements were made close to the melting points where the densities of waxy liquids are uncertain and tend to vary with time after melting. For calculating densities at temperatures well above the melting point it is believed that densities derived from Equation (7) may be more reliable than those based on the experimentally reported densities.

The relationship expressed by Equation (7) may be assumed to be independent of isomerization as indicated by the following values of $v_1\omega_1$ for isomers:

n. butane	**11.62**	**i. butane 11.69**
n. pentane	**14.07**	**i. pentane 14.08**
n. hexane	**16.52**	**2, 3 dimethylbutane 16.32; neohexane 16.48**

This approximate constancy of $v_1\omega_1$ is also found for isomers in the other series studied.

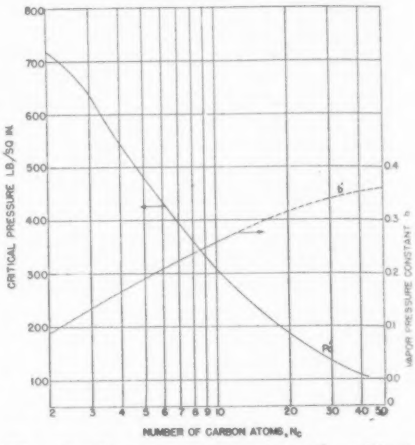

Fig. 1—Vapor pressures and critical pressure constants of the paraffins

Once $(v_1\omega_1)$ or (ρ_1/ω_1) is established, either from a relationship such as Equation (7) or from experimental density and critical temperature data, the critical volume is readily calculated from the value of ω at the critical point. Thus,

$$v_c = (v_1\omega_1)/0.0440 \quad \ldots\ldots (8)$$

$$\rho_c = (\rho_1/\omega_1)(0.0440) \quad \ldots\ldots (9)$$

A method for estimating critical densities which requires knowledge of only structural formulas was developed by Meissner and Redding[9]. Equations (8) and (9) may be used as an alternate method for obtaining critical densities or conversely, the critical density may be calculated by the method of Meissner and Redding and Equation (8) or (9) used to evaluate $(v_1\omega_1)$ or (ρ_1/ω_1).

Generalization of Vapor Pressure Constant b

It was found that for the other series of homologs which were studied the vapor pressure constants b, when plotted against number of carbon atoms, form curves which differ by approximately constant increments from the corresponding values for the paraffins. Accordingly the constant b for any homolog may be approximated by the following equation:

$$b = b' + \Delta b \quad \ldots\ldots (10)$$

where b = the constant for a compound containing n_c carbon atoms

b' = the constant b for the paraffin containing n_c carbon atoms

Δb = a constant characteristic of the homologous series. Values of Δb for 14 series have been evaluated and are given in Table IV. The constant b for any member of one of these series is readily estimated by means of Equation (10) and Table III or Fig. 1. Although for

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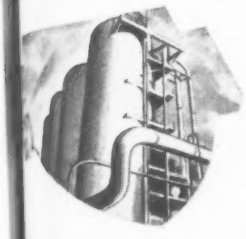

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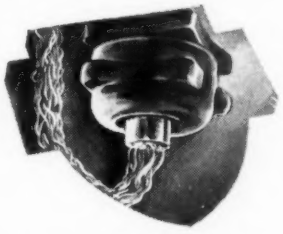

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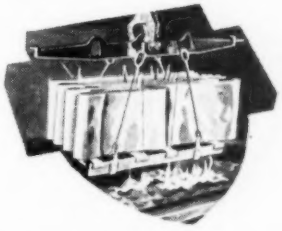

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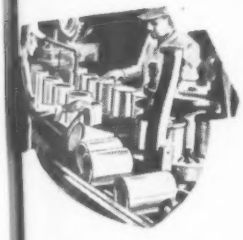

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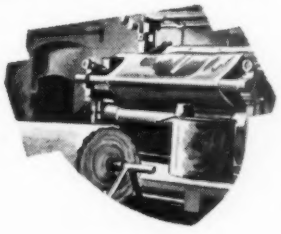

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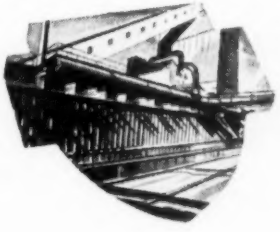

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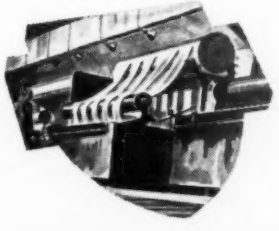

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some of the series Equation (10) can be verified for only the first few members, the general magnitude of the deviations does not appear much greater than the probable errors involved in the data.

TABLE IV—Critical and Vapor Pressure Constants

	Δp lb/sq in.	c	Δb
Acids	300	0	0.05
Alcohols	480	0	0.22
Aldehydes	250	0	0.05 (?)
Amines, primary	69	—1.3	0.12
Amines, secondary	80	0	0.12
Aromatic hydrocarbons (monocyclic)	830	—3.0	—0.02
Esters	60	—1.6	0.09
Ethers	0	0	0.04
mono halogenated parafins	47	—1.0	0.08
Ketones	180	0	0.05
Napthenes	970	0	—0.03
Nitriles	0	0	0.02
Phenols	1,360	— 3	0 (?)
Olefins, mono	63	0	0.01

General Correlation of Critical Pressure

Meissner and Redding[9] developed a general method for predicting the critical pressure of any substance from a knowledge of only the critical temperature and critical volume. Thus,

$$p_c=\frac{20.8\,T_c}{(v_c-8)} \qquad (11)$$

The critical volume may be calculated from the parachor as discussed by Meissner and Redding or determined from a single observation of liquid density by means of Equation (8). With the exception of water, maximum errors of 15% are encountered and the majority of the results are within 10% of the experimental values.

An alternate procedure for estimating critical pressures is outlined below which appears somewhat more reliable than the general method described above for the 15 series of organic compounds studied. As the number of carbon atoms in an homologous series is increased above 2, the critical pressure progressively decreases. This relationship is shown graphically for the paraffin hydrocarbons in Fig. 1. For series of compounds other than the paraffin hydrocarbons, Fig. 1 may be used with the following equation for estimating the critical pressure,

$$p_c=p'_c+\frac{\Delta p}{n_c+c} \qquad (12)$$

where p_c is the value for a compound containing n_c carbon atoms and p'_c is the value read from Fig. 1 corresponding to n_c and Δp and c are constants characteristic of the homologous series, given in Table III.

For several of the series Equation (12) is not verified beyond the first few members. However, the deviations in general are not much greater than the probable errors of measurement which are believed to be rather large in many cases. The form of the equation is such that the critical pressures of high molecular weight compounds tend to approach those of the corresponding paraffins. This trend seems logical and is supported by the available data.

In Table V are values of the critical pressures of various alcohols calculated from Equation (12) for comparison to values calculated by the methods of Meissner and Redding and the experimentally observed values where available. It will be noted that for this series both methods give fair agreement with the experimental values except for the lowest homolog which generally shows exceptional behavior. The difference between the two methods increases with increased molecular weight and results obtained on various series are interpreted as indicating that, where sufficient data are available to establish the constants Equation (12) is a somewhat more reliable method of extrapolation than the more general equation of Meissner and Redding.

Estimation of Critical Temperatures

Watson (12) proposed a method for calculating the critical temperature of a non-polar compound using an empirical equation which requires knowledge of the normal boiling point, molecular weight and liquid density at the normal boiling point. This latter property may be estimated from a single value of the liquid density at any conditions by means of the general expansion factor chart (13) or Equation (6). This method of estimating critical temperatures is satisfactory for non-polar substances but breaks down for polar materials.

More general equations, applicable to nearly all substances, were proposed by Meissner and Redding (9). These equations are convenient to use and give good results for a variety of compounds but are perhaps slightly less reliable for nonpolar substances than the method of Watson.

The relatively high accuracy of the expansion factor generalization for liquid densities and the validity of Equation (7) for the paraffins in the range where densities are reliable suggests an alternate method for estimating critical temperatures of the higher homologs of a series. Combining Equations (5) and (6) and solving for T_c,

$$T_c=\frac{0.0838\,T}{0.1745-(v_1\omega_1)/v} \qquad (13)$$

where v = the molal volume at temperature T under conditions such that Equation (6) is applicable.

If generalizations are established for $v_1\omega_1$, Equation (13) may be used to calculate the critical temperature of a compound from a reliable molal volume v measured at a temperature T which is well above the melting point but below a reduced temperature of 0.65.

From a study of the various hydrocarbon series it appears that the addition of a CH_2 group to a compound increases its value of $v_1\omega_1$ by 2.44, the same increment observed in the paraffin series. Thus,

For mono olefins
$$v_1\omega_1=1.1+2.44\ n_c \qquad (14)$$
For monocyclic aromatics
$$v_1\omega_1=-3.0+2.44\ n_c \qquad (15)$$

Equations (14) and (15) are in good agreement with the reported density and critical temperature data for the compounds reported by Doss (5) and show no consistent variation with isomerization. Accordingly the critical temperature of a member of either of these series may be estimated from its liquid density by combination of Equation (13) with (14) or (15).

For series of polar compounds the increment in $v_1\omega_1$ for the addition of a CH_2 group tends to vary in the lower members and approach a value of 2.44 with increased molecular weight. This behavior is expressed by the general relationship

$$v_1\omega_1=a+2.44n_c+m\ log\ n_c \qquad (16)$$

where a and m are constants characteristic of the series.

For the hydrocarbons $m=0$.
For the alcohols
$$v_1\omega_1=2.89+2.44\ n_c-1.23\ log\ n_c \qquad (17)$$

Equations similar to (17) may be derived for other series of compounds and used in conjunction with Equation (13) for

TABLE V—Critical Properties of the Alcohols

	Critical Temperature °K			Critical Pressure atmospheres			Critical Volume v_c (cc)/(g-mole)		
	Eq. (17) and (13)	M&R	°Expt.	Eq (12)	M&R	°Expt.	Eq. (17) and (8)	M&R	Expt.°
Methyl	575.4	505.8	513.2	78.5	93.7	78.7	121.1	120.2	117.8
Ethyl	515.1	520.2	515.2	65.1	66.8	63.1	168.2	170.0	167.1
n. Propyl	537.6	540.0	536.9	54.5	52.3	50	218.7	222.7	220
Isopropyl	505.6	524.1	508	54.5	50.8	53	218.7	222.7	...
n. Butyl	550.0	560.5	560	45.3	43.2	48.4	270.7	278.1	...
Isobutyl	539.3	549.8	538	45.3	42.3	48	270.7	278.1	...
sec. Butyl	550.9	541.8	538	45.3	41.7	...	270.7	278.1	...
tert. Butyl	515.6	524.6	508	45.3	40.4	...	270.7	278.1	...
Isoamyl	567.2	573.6	580	39.3	36.4	...	323.4	335.9	...
tert. Amyl	560.1	544	545	39.3	34.5	...	323.4	335.9	...

°Experimental values and fundamental data from International Critical Tables[8].

estimating the critical temperatures of higher homologs from density measurements.

The results of calculations of this type for the alcohols on which critical data are available are summarized in Table V. Critical temperatures are calculated by Equations (17) and (13) for comparison with the experimental values and the values calculated by the equation of Meissner and Redding. Similar comparisons are shown for critical volume calculated from Equations (17) and (8).

It will be noted that there is little to choose between the two methods of calculation for this series of compounds for either critical temperatures or volumes if consideration of the first homolog is eliminated. The calculated critical volumes differ increasingly with increased molecular weight. Although there are no substantiating data it is felt that the general procedure of Equations (17) and (8) may be somewhat more reliable for the critical volumes of high boiling compounds because of the fact that it is more directly based on liquid density measurements.

As previously mentioned, still another approach is to calculate the critical volume from the structural formula by the method of Meissner and Redding and evaluate $v_1\omega_1$ from Equation (8). The critical temperature may be calculated from Equation (13) with no experimental data other than a single liquid density. This method may be used where the boiling point is unknown and difficult to evaluate. By combination with the equations of Meissner and Redding relating critical temperature and boiling point, a method for predicting a boiling point from a liquid density measurement and the structural formula results.

In the present state of experimental critical data these various methods of calculating critical properties are best considered as alternates to be checked against each other and the available data to arrive at the best estimate for a particular problem. The choice of the best method of calculation is to a great extent dependent upon the type and reliability of the fundamental data available for the compound in question and its homologs.

Vapor Pressures Below 0.1 mm Hg

In certain instances it is necessary to evaluate vapor pressures considerably below 0.1 mm Hg. Equation (1) cannot be safely extrapolated to low vapor pressures because the exponential function reaches a maximum of 1.0 at $T_r = b$ and then reverses. This behavior is not encountered at pressures above 0.1 mm. Hg.

For vapor pressures below 10 mm of Hg, little error is introduced by assuming that the vapor follows the ideal gas law and that the Clausius-Clapeyron equation is valid. Thus,

$$\frac{d\ ln\ p}{dT} = \frac{\lambda}{RT^2} \quad \ldots\ldots (18)$$

or

$$\frac{d\ ln\ p}{dT_r} = \frac{\lambda}{RT_cT_r^2}$$

Watson[13] developed a general equation for the calculation of the heat of vaporization at any temperature when only one value is known. The proposed expression is

$$\lambda = \frac{\lambda_1(1-T_r)^{.38}}{(1-T_{r_1})^{.38}} = \lambda_0(1-T_r)^{.38} \quad \ldots (19)$$

Equation (8) simply states that the ratio $\lambda/(1-T_r)^{.38}$ at any temperature is a constant equal to the heat of vaporization at the absolute zero. In the absence of direct experimental data an accurate value for the heat of vaporization may be obtained by differentiating Equation (1) with respect to reduced temperature at a low pressure, substituting in Equation (18) and solving for λ. From this value and the reduced temperature, the heat of vaporization at the absolute zero is obtained. Substituting Equation (19) in (18) and integrating results in

$$ln\frac{p_2}{p_1} = \frac{\lambda_0}{RT_c}\int_{T_{r_1}}^{T_{r_2}} \frac{(1-T_r)^{.38}}{T_r^2}dT_r \quad \ldots\ldots (20)$$

Equation (20) may be used to extend vapor pressure values to infinitesimally small quantities. The reference pressure and temperature is obtained at a value near 10 mm of Hg from Equation (1). Equation (20) has been integrated graphically from T_r of 0.3 to 0.7, and the values for

$$\int_{0.3}^{T_r} \frac{(1-T_r)^{.38}}{T^2}dT_r$$

are given in Table VI and plotted in Fig. 2.

TABLE VI

T_r	$\int_{0.3}^{T_r} \frac{(1-T_r)^{.38}dT_r}{T_r^2}$
.30	0
.32	.1810
.34	.3388
.36	.4776
.38	.6002
.40	.7093
.42	.8067
.44	.8941
.46	.9729
.48	1.0440
.50	1.1086
.52	1.1672
.54	1.2207
.56	1.2695
.58	1.3142
.60	1.3552
.65	1.4438
.70	1.5153

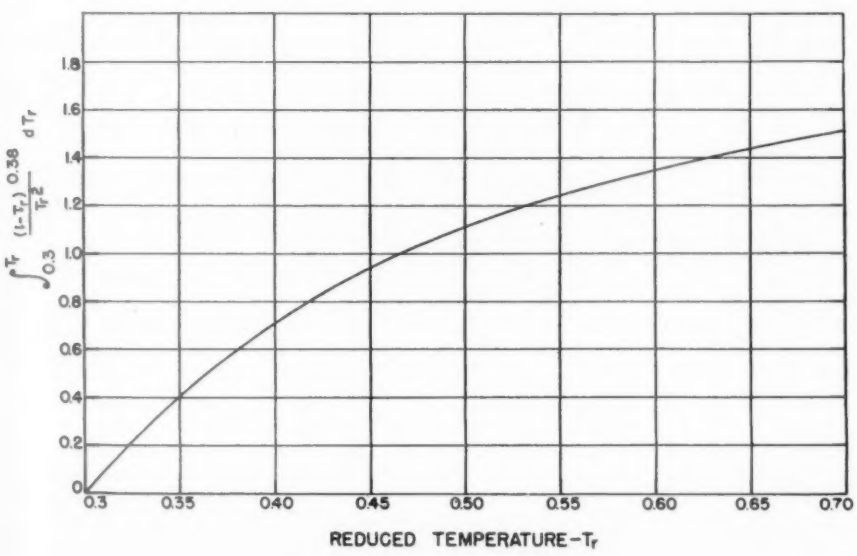

Fig. 2—Vaporization integral

Equations (1) and (20) are found to be in good agreement for the vapor pressure range from 0.1 – 100 mm of Hg. For higher pressures Equation (1) is recommended while for lower pressures Equation (20) is preferable.

Utility of Methods

The vapor pressure equations are most conveniently used by plotting charts on semi-logarithmic paper with vapor pressures as ordinates on the logarithmic scale and temperature on the uniform scale. The resulting lines are somewhat curved and it is desirable to plot separate curves for the high and low pressure regions.

Complete vapor pressure charts for hydrocarbons are readily calculated from

the data of Table III. The lines on such a chart may represent particular compounds or may be more closely spaced to correspond to specified normal boiling points. Such a chart, derived from the constants for the normal paraffins may be used satisfactorily for estimating the change of boiling point with pressure for other series of hydrocarbons and for the average boiling points of petroleum fractions. Charts plotted in this manner are more accurate than the Cox type of plot and more convenient than the Brown-Coats type.

For conversion of vacuum distillation temperature to normal boiling points it is convenient to plot normal boiling points as ordinates and observed temperatures as abscissas with lines of constant pressure. This is in effect the Brown-Coats method of plotting. Such a chart for hydrocarbons is readily derived from the data of Table III. Similar charts may be developed for other types of compounds by means of the generalizations relating the constants of the vapor pressure equations.

The applications of these methods to calculating vaporization equilibrium constants will be discussed in future articles. The relative volatilities at moderate pressures of compounds which may be assumed to form ideal solutions may be calculated directly from Equation (1). Thus, for two compounds 1 and 2 which are not greatly different in boiling point and critical temperature the difference in the exponential terms may be neglected at all except low pressures. Then

$$\log \alpha = \log \frac{p_1}{p_2} = (B_1 - B_2) - \frac{(A_1 T_{c1} - A_2 T_{c2})}{T} \quad (21)$$

Equation (21) is convenient for accurately evaluating small relative volatilities and expresses α as a simple function of temperature. It is a satisfactory approximation for low boiling compounds at moderately high pressures. For high boiling compounds at low pressures the exponential terms should be included in the equation.

The methods for estimating critical properties together with previously published methods permit complete interrelation of boiling points, critical properties, liquid densities and molecular weights by several alternate procedures. These relationships may be used in various ways, depending on the data available, to insure the most reliable and consistent estimated values.

Convenient tables or charts of thermal expansion and compressibility are readily derived for specific compounds or series from Equations (4) and (5). This method of correlation is particularly advantageous in that it leads directly to a reliable general method for handling the densities of wide-boiling mixtures which will be discussed in a later article.

Acknowledgment

This work was made possible by the financial support and sponsorship of the Wisconsin Alumni Research Foundation.

Nomenclature

A, B, a, b, c, m = constants
b' = vapor pressure constant for paraffin of n_c carbon atoms in Equation (10)
e = base for natural logarithms
n_c = number of carbon atoms in compound
p = vapor pressure
p'_c = critical pressure for paraffin of n_c carbon atoms in Equation (12)
T = absolute temperature
v = molal volume
α = relative volatility
λ = molal heat of vaporization
ρ = liquid density
ω = expansion factor, a dimensionless function of only reduced temperature and reduced pressure
$(v_1\omega_1)$ = product of expansion factor and molal volume, a characteristic constant for each compound
(ρ_1/ω_1) = ratio of density to expansion factor, characteristic constant for each compound
Δb = vapor pressure constant for homologous series
Δp = critical pressure constant for homologous series

Subscripts

1 = initial or reference condition or component 1
2 = final condition or component 2
c = critical property
o = absolute zero value
r = reduced conditions
B = normal boiling point

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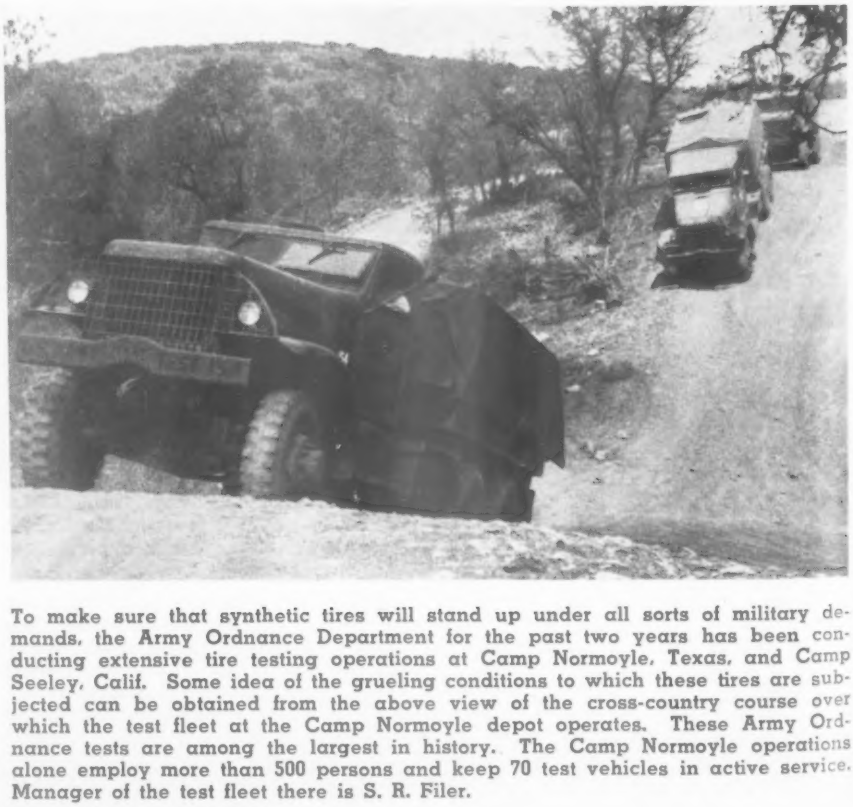
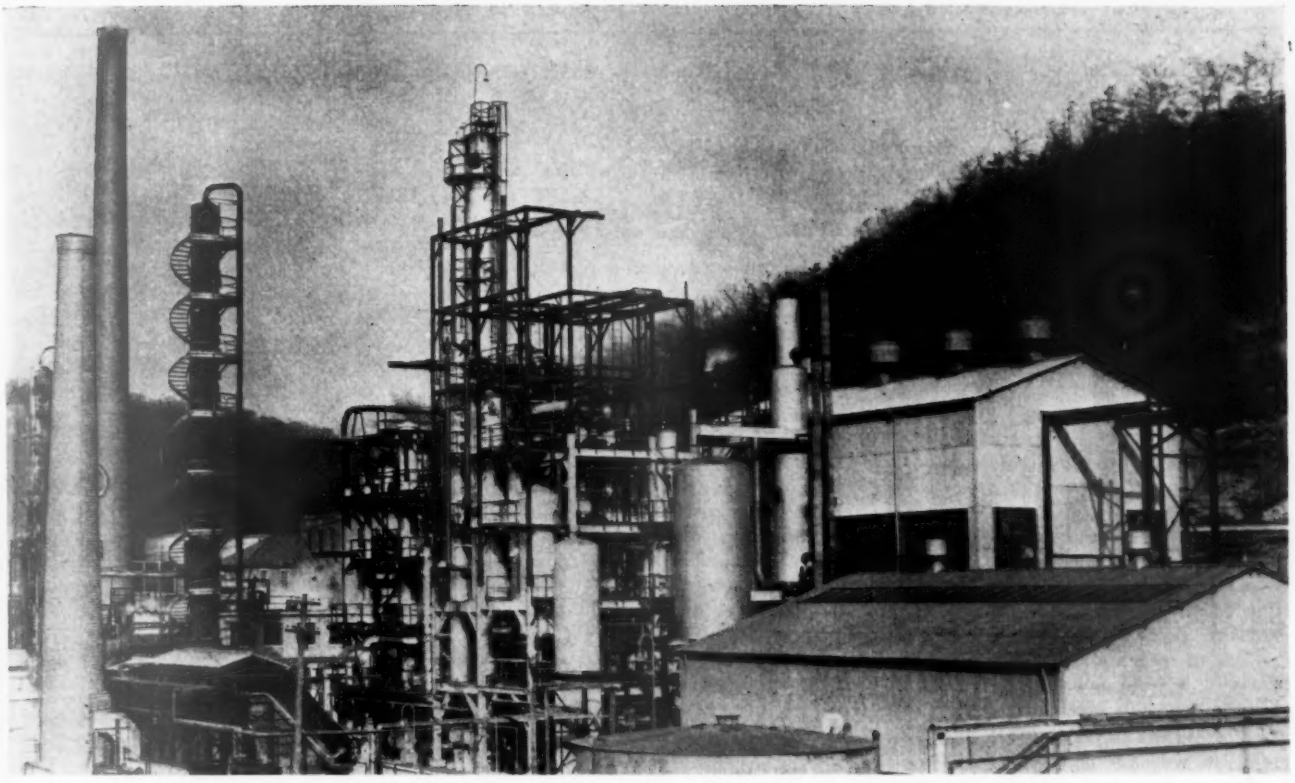
Synthetic Tires Put "Through the Mill" By Army Ordnance Test Fleet



To make sure that synthetic tires will stand up under all sorts of military demands, the Army Ordnance Department for the past two years has been conducting extensive tire testing operations at Camp Normoyle, Texas, and Camp Seeley, Calif. Some idea of the grueling conditions to which these tires are subjected can be obtained from the above view of the cross-country course over which the test fleet at the Camp Normoyle depot operates. These Army Ordnance tests are among the largest in history. The Camp Normoyle operations alone employ more than 500 persons and keep 70 test vehicles in active service. Manager of the test fleet there is S. R. Filer.



General view of furfural refining and dewaxing units of new lubricating oil plant of Quaker State Oil Refining Corp. at Emlenton, Pa.

Solvent Dewaxing and Recrystallizing Units Included in New Lubricating Oil Refinery

By Emil E. Ebner and F. T. Mertens***

A NEW LUBRICATING OIL and wax plant for the production of low pour point, high viscosity index, motor, heavy duty and aviation oils and for the manufacture of high purity, oil-free crystalline and micro-crystalline waxes, has been placed in operation by Quaker State Oil Refining Corp. at its Emlenton, Pa., refinery.

The capacity of the clay percolation plant was also increased by the addition of another clay regenerating furnace to increase the output of low carbon residue bright stocks and of light colored grades of micro-crystalline waxes.

The new plant consists of methyl ethyl ketone-benzol solvent dewaxing and wax recrystallizing units and a furfural solvent extraction unit.

The MEK-benzol solvent plant is designed to permit simultaneous dewaxing of raw lubricating oil fractions from Pennsylvania crude into finished low pour point oils, and recrystallizing of crude waxes into finished de-oiled and fractionated waxes in a wide variety of melting points. This simultaneous operational feature is unique and the installation is the first of its kind.

Quaker State engineers worked out the design of the solvent dewaxing and recrystallizing plant with Texaco Development Corp., who license the processes, and Foster Wheeler Corp. was awarded the contract for its detailed design and construction. The design and operation of the wax de-oiling and recrystallizing sections were evolved from several years of laboratory research and development work. The earlier phases of this work led to the construction in 1936 of a MEK-benzol dewaxing plant at the McKean refinery of Quaker State. This was the first commercial application of ketone-benzol solvent dewaxing and de-oiling in the Pennsylvania refining area. While this earlier plant was primarily intended for dewaxing and de-oiling, it was also used for full scale recrystallization and purification of waxes, following procedures developed in the laboratory. These full scale trials from 1936 thru 1939 confirmed the laboratory work that the ketone-benzol solvent process could be utilized to produce closely fractionated waxes of very low oil content with greater efficiency and precision than was possible by the conventional methods of sweating, repressing or multiple-centrifuging.

Solvent Extraction Efficient

The furfural solvent extraction unit of the new plant follows the same general design as two similar units which were installed at the McKean and St. Mary's refineries of the company in 1938-39. Extensive laboratory research had demonstrated that motor and aero oils refined by conventional methods of distillation and clay treatment still retained small concentrations of unstable constituents which, on exposure to elevated temperatures and aeration in engines, oxidized readily with formation of sludges and varnish-like deposits. Solvent extraction was found to be a precise means for removing these readily oxidizable constituents to produce highly sludge and varnish resistant engine lubricating oils.

After the basic features of the new plant at Emlenton were decided upon, Foster Wheeler Corp. prepared numerous detailed studies as to the most economic design. These included fired heaters versus steam for the solvent recovery systems and the types of drives most suited for the numerous pumps and refrigeration compressors. After making utilities balances on several types of operation, the decision was made to install a high pressure steam generating plant with provisions for the possible future installation of an electric power generating unit. Considerable planning was required on the arrangement of the equipment in the plant site, which was located on a restricted strip of land

*General Superintendent of Refineries, Quaker State Oil Refining Corp.

**Process engineer, Foster Wheeler Corp.

between a hillside and the Allegheny River.

While the final engineering and design work in the Emlenton plant was in progress, war was declared. While the need for high quality heavy-duty and aviation oils and special waxes was recognized, the greater immediate demand on the petroleum industry was for 100 octane gasoline, toluene and butadiene. The priority situation accordingly demanded that every effort be made to utilize second-hand or reconstructed equipment. Fortunately, Quaker State had sometime previously purchased the solvent dewaxing plant of a refinery in process of liquidation. It was found possible to re-condition and utilize the major portion of this old plant in the new construction program. Considerable tankage and miscellaneous equipment was also secured by salvage and relocation of many items from other Quaker State refineries. This extensive program of salvage and conversion of existing equipment resulted in saving several hundred tons of critical new materials and equipment.

Referring to the simplified flow diagram, it will be noted that the new dewaxing and recrystallization wax plant comprises 7 major sections:

1. Direct expansion ammonia chilling.
2. Double pipe scraped surface exchangers and chillers for both the solvent dewaxing and the wax recrystallizing process sections.
3. Continuous vacuum dewaxing filters.
4. Tubular exchangers and chillers to chill wash solvent.
5. Flue gas generation, circulating and chilling.
6. Four complete product recovery systems for: a. Dewaxed oil, b. slack wax, c. slop wax filtrate. d. product wax.
7. Solvent-water separating and recovery system.

Two Separate Units

The solvent dewaxing and wax recrystallization process section is essentially two separate units which may be operated in series or in parallel flow. Several combinations of operations may accordingly be carried out. Reduced wax distillate can be charged to the dewaxing unit to produce a neutral oil of −10° F. pour point. (This dewaxed neutral is subsequently extracted in the furfural refining process unit to yield a lubricating oil having a viscosity index of 110 to 115.) The "slack wax" from the dewaxing operation, averaging 125° F. melting point and containing about 6% oil, is simultaneously charged to the recrystallizing unit with additional solvent where at a filtering temperature of 30° F. it is de-oiled to yield crystalline wax having a melting point of 130-132° F. AMP and an ASTM oil content of well under 1%. As an alternate operation, Pennsylvania cylinder stock may be dewaxed to 0° F. pour point, yielding a petrolatum of about 128° F. M.P. with about 8% oil content. This petrolatum may then be recrystallized with additional solvent at a temperature of 60° F., yielding a micro-crystalline wax of high melting point and an oil content of 0.5% or less.

The solvent dewaxing and recrystallization units are sufficiently flexible that cylinder stock can be dewaxed in the dewaxing unit while paraffine slack wax can be charged to the recrystallizing unit for production of finished crystalline waxes. Alternately, it is possible to

TABLE I — Average Operating Data For New Lubricating Oil and Wax Plant

	Reduced Wax Distillate	Extracted & Filtered Cylinder Stock
Charge Oil:		
API Gravity	32.7	27.7
SSU Viscosity	152 @ 100°F	136 @ 210°F.
Pour Point °F.	90	70
P.M. Flash	430	530
Dewaxed Oil:		
Yield % by vol.	79	88
API Gravity	30.4	27.2
SSU Viscosity	195 @ 100°F	146 @ 210°F.
P.M. Flash	435	525
Pour Point °F.	0 to 5°F.	10-15°F.
Color	3D NPA	2 TR
Carbon	.....	.95%
Slack Wax		
P.M. Flash	430	520
Melting Point (ASTM)	126.5	129
Per Cent Oil Content	6.5	8.0

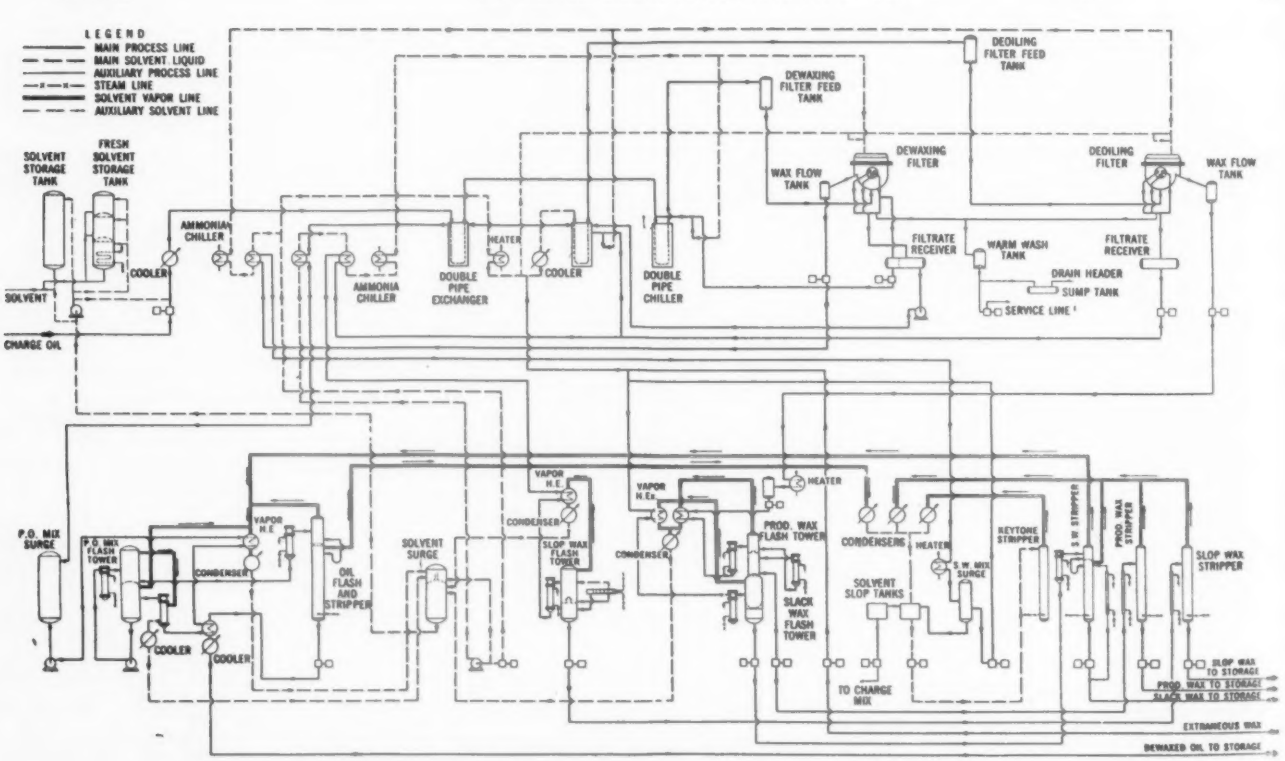


Fig. 1—Flow chart of dewaxing and wax recrystallizing units

Invention lights the way—

An invention kept secret is like a lighted candle set under a bushel An invention disclosed is like a lighted candle set on a candlestick; it is useful to all

A wise inventor today doesn't hide his invention and he doesn't risk theft

He discloses it in the U. S. Patent Office, thereby adding to the sum of knowledge and spurring thousands of other inventors to greater efforts Such competition speeds progress

In return for his disclosure the inventor is given a patent which protects his rights He can show his goods without fear, he can develop his invention to commercial usefulness in safety

For more than a quarter century, Universal research has been making vital contributions to the oil refining art All have been fully disclosed in the patent office Processes based upon them are the backbone of the refining industry in peace and in war

All of them are available to all refiners under Universal license

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REFORMING	DEHYDROGENATION
HYDROGENATION	POLYMERIZATION
ALKYLATION	UNISOL TREATING
ISOMERIZATION	RETREATING
THERMAL CRACKING	POLYTREATING
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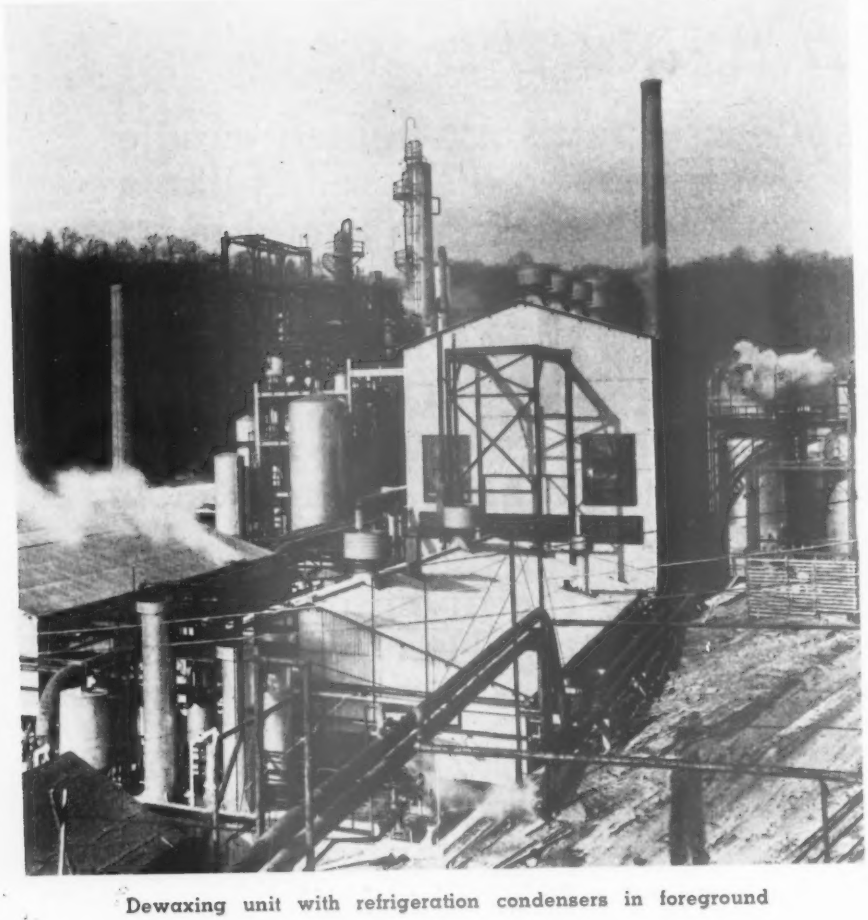


Dewaxing unit with refrigeration condensers in foreground

process neutral oil in the dewaxing unit and at the same time to recrystallize crude petrolatum to yield micro-crystalline type waxes.

By selective control of solvent ratios and chilling temperatures it is possible to produce neutral oils having pour points from plus 25° F. to as low as minus 30° F., and viscous stocks having pour points from plus 25° F. to as low as minus 20° F. Similarly, crude paraffine waxes can be solvent fractionated to yield oil free crystalline waxes having melting points as low as 110° F and as high as 140° F. Petrolatum can be recrystallized and fractionated to yield micro-crystalline type waxes with melting points ranging from 110° F. up to 160° F. or higher.

The solvent dewaxing unit of the plant has a designed capacity of 1000 to 1500 B.P.S.D. depending upon the type of charge stock and the pour point to be produced. The wax recrystallization section has a designed capacity of 200 to 275 B.P.S.D. depending upon the type of crude wax charge and the type of product wax desired. Average plant operating data are shown in Table I.

The flow through the dewaxing unit is essentially as follows, as shown in Fig. 1. The charge oil is mixed with solvent, the ratio depending upon the viscosity of the charge oil, and held constant by a ratio flow recording controller. The mixture is first cooled by water in a shell and tube exchanger and then by cold dewaxed oil filtrate in several double pipe type exchangers. The partially cooled mixture passes thru the inner pipe of exchangers, wherein revolving spring loaded scrapers keep the surface free of wax accumulation thereby assuring constant high heat transfer rates. The charge mix is finally chilled to the desired filtering temperature by the use of direct expanding ammonia in additional double pipe, scraped surface chillers. The cold mix containing the crystallized waxes then passes to a gravity flow filter feed tank where the amount of charge admitted to each filter is controlled by liquid level instruments operating butterfly type valves.

The liquid oil passes thru the filter cloth of the revolving filter drums and is subsequently pumped from the filtrate receiver through the previously mentioned double pipe exchangers, whereby considerable refrigeration is recovered, and then passes to a surge tank before it is charged to the solvent recovery system.

The wax cake, commonly called "slack wax", collects on the surface of the revolving drums of the vacuum dewaxing filters, where it is continuously washed with cold solvent to displace oil held in the interstices of the wax crystals. The washed wax cake is continuously removed from the filter drums and pumped, by means of a reciprocating steam pump, thru a heat exchanger where some refrigeration is recovered by transfer to incoming wash solvent. The wax cake is then heated by exhaust steam to a completely liquid state to aid in settling out in the surge tank any moisture that may have entered the filtering system.

The "slack wax" mix may then be either charged to the recovery system for removal of the solvent or may be charged to the wax recrystallization unit for de-oiling and fractionating. If the latter operation is followed, the wax is mixed with additional solvent to the desired dilution, cooled in a shell and tube heat exchanger with water, and finally chilled in a double pipe heat exchanger to the desired filtering temperature. The filtering temperature varies from plus 25° F. to plus 60° F. depending upon whether the slack wax is of a crystalline or amorphous character and also upon the desired final melting point of the product wax. The chilled wax mix is then processed through the recrystallization unit in a manner similar to that already described for the dewaxing unit. The filtrate containing the oily and undesirable low melting point portion of the "slack wax" that has passed thru the filter cloth is used to precool some of the wash solvent before being charged to the recovery section for removal of solvent. The product wax cake is heated to approximately 150° F. with exhaust steam to liquefy the wax before it is run thru the recovery system.

Dewaxed Filtrate Preheated

The 4 recovery systems use live and exhaust steam for the removal of solvent. The dewaxed oil filtrate is preheated by solvent vapor and by countercurrent stripped dewaxed oil before being flashed at atmospheric pressure. In order to obtain maximum heat economy, a system of double effect evaporation, as illustrated on the flow diagram, is employed. Steam stripping is used for removal of final traces of the dewaxing solvent.

The other three recovery systems for the "slack wax", the product wax and the oily or "slop wax" filtrate, use exhaust steam to evaporate off 75-80% of the solvent and then follow with live steam reboiling to remove essentially all of the remaining solvent before final steam stripping of each stream. In these 3 sections, the evaporation is all carried out at atmospheric pressure since the quantities of solvent handled are not sufficiently large to justify a double effect evaporating system. Since the flowing quantities of either of these 3 streams are relatively small, finned tube heaters are used, heated with live steam, to aid in maintaining satisfactory temperatures at the base of the stripping columns. The net flow of product from the base of the stripper is level controlled to storage, and pressure gov-

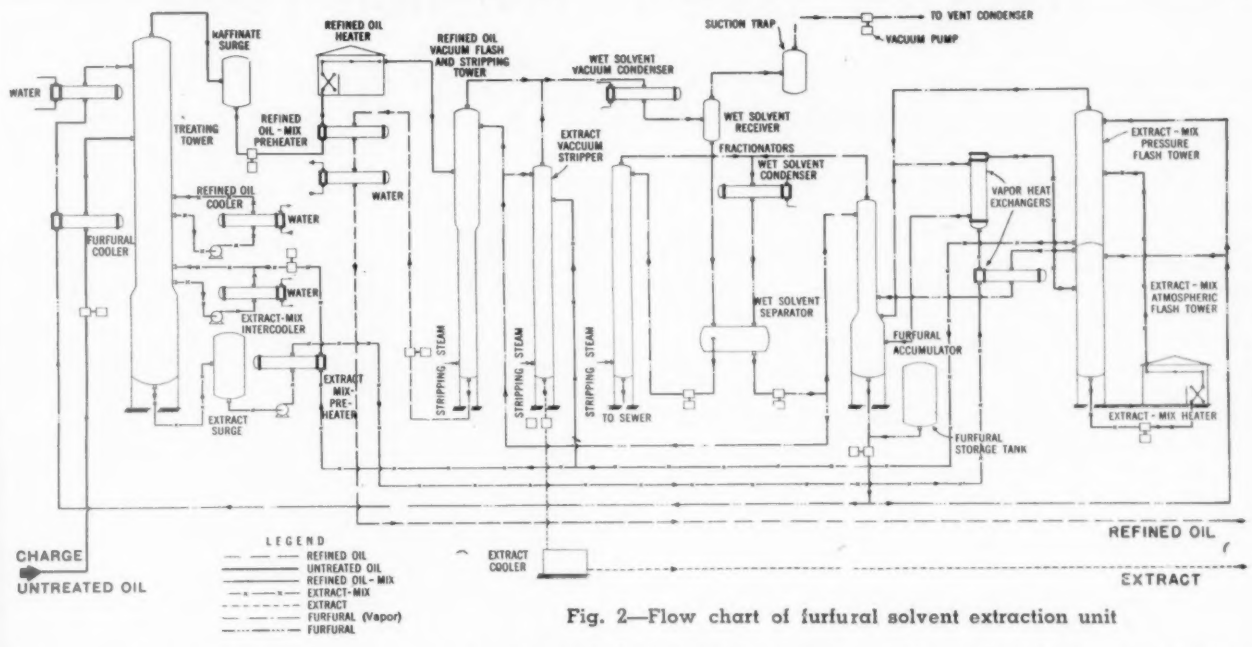


Fig. 2—Flow chart of furfural solvent extraction unit

ernors are used to aid in maintaining circulation of the stripper bottoms back thru the reheaters.

The furfural refining unit is similar to the two units previously designed and constructed by Quaker State in 1938-39. See Fig. 2. The main improvement has been in the design of the extraction tower in order to reduce the quantity of furfural required to yield the desired quality of product. This new tower is the first one of its kind installed and is the outgrowth of a study undertaken by the engineers of Texaco Development Corp., Quaker State and the Foster Wheeler Corp.

The tower contains 8 nests of Raschig rings, each 5 ft. in depth, with specially designed trays above each nest to assure even distribution of the down-flowing solvent, without interfering with the upflowing refined oil or raffinate stream. By the use of two intercoolers to cool the descending stream of extract mix as desired, and regulation of the temperatures of the charge oil and treating solvent, a very even temperature gradient is maintained throughout the tower. It is possible to vary at will the temperature in any part of the treating tower to obtain optimum results for any particular charge stock.

Furfural Removed

The untreated oil is preheated to the desired temperature by either hot furfural or exhaust steam and charged to the middle of the treating section of the extraction tower. The furfural at a temperature ranging from 200°F. to 300° F. depending upon the stock being refined, is introduced just above the top nest of Raschig rings. The furfural flows downward thru the oil filled packing countercurrent to the ascending stream of charge.

The raffinate, together with a small quantity of solvent, flows from the top of the extraction column to a surge tank. The mix is pumped (controlled by a rate of flow controller) through a heat exchanger and direct fired heater to the vacuum flash and stripping column where all traces of furfural are removed from the refined oil.

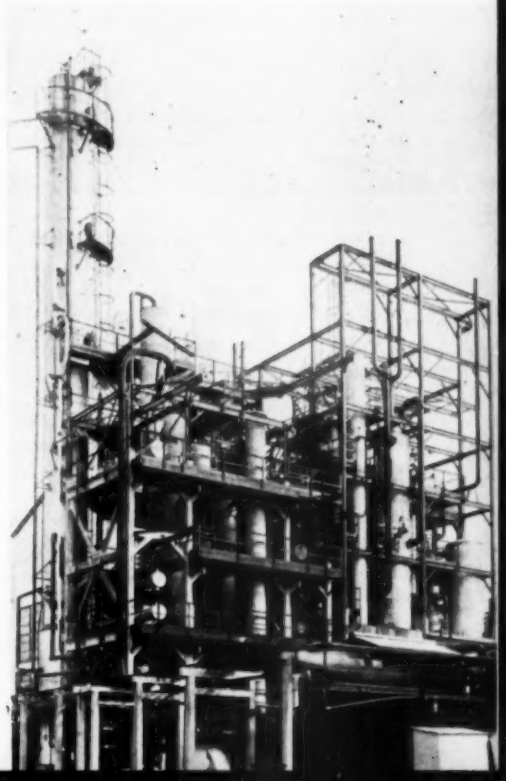
The extract solution, containing most of the furfural solvent, flows from the bottom of the settling section of the treating tower to a surge tank before being charged to the recovery section. Since fuel costs are quite high, a double effect evaporation system is employed, together with a final steam stripper.

The furfural extraction unit was designed to charge from 1000 to 1750 B.S.P.D. depending upon the type of charge stock and the degree of extraction desired. Table II shows typical results of 10-day trial runs. The plant was brought on stream in late September and after the usual "tuning up" period has been operating with satisfaction both as to quality of product and capacity.

TABLE II — Typical Results of 10-Day Trial Runs of New Furfural Extraction Unit

	Dewaxed Neutral Oil	Raw Cylinder Stock
Charge Oil:		
API Gravity	30.4	26.0
SSU Viscosity	195 @ 100°F.	161 @ 210°F.
P.M. Flash	430	525
% Furfural Applied by Volume	159	160
Treating Tower Temp.		
Top °F.	235	275
Feed Tray °F.	199	216
Bottom °F.	134	179
Refined Oil Yield Volume %	92.0	94.0
Refined Oil		
API Gravity	32.9	27.3
SSU Viscosity	172 @ 100°F.	151 @ 210°F.
P.M. Flash	430	535
Viscosity Index	113	105
Extract		
API Gravity	7.8	5.8
SSU Viscosity	85 @ 210°F	3100 @ 210°F.

Treating tower and recovery systems for furfural and dewaxing units



High Flash or 'Safety' Aviation Fuels*

New Refining Processes Provide Means for Manufacturing Large Volumes of Suitable Fuels of this Type

High-flash or "safety" aviation fuels are being studied as a means of eliminating fire hazards created by the highly volatile aviation fuels in general use. These new type fuels can be made available in greatly increased quantities through some of the new refining conversion processes. Flash point and spontaneous ignition temperature of fuels are two factors intimately connected with aircraft fire hazards, and are the principal characteristics considered in the so-called safety fuels. In addition the qualities which influence engine performance must be taken into account, such as octane number, volatility and heating or combustion value.

The high flash fuels are difficult to vaporize, however, and therefore are not satisfactory in regular carbureted motors; injection systems are required for satisfactory performance.

*By Matthew Van Winkle***

IT HAS LONG BEEN recognized that the high-volatile aviation fuels have presented a distinct hazard in flight, during refueling, or after a crash because of their inflammability. Many of the fatalities occurring as the result of airplane accidents are caused by the flashing and burning of the fuel after a crash. The danger of fire is always present in pouring or pumping the fuel into the aircraft fuel tanks. At various times investigations have been conducted to determine the manner in which such fires start, and probably the most classical of these investigations were those conducted by the Army Air Forces at Wright Field. In these experiments full-sized airplanes were warmed up, run down an incline, and crashed into a concrete wall, the crash being photographed with high-speed cameras. Although these experiments were valuable relative to the particular type of airplane and fuel used, the conclusions obtained were not adaptable to all types of airplanes and fuels.

Although the cause of fires after a crash may be due to the ignition of lubricating oil coming in contact with exhaust or other hot engine parts[1], or the flashing of the fuel upon similar contact, the actual damage results from the explosive burning of the gasoline. The volatile gasoline of the type in general use today tends to burn explosively because of its low flash point and high volatility, and this has caused a great amount of interest in the so-called "safety" or "high-flash" aviation fuels.

There has been much discussion concerning the adaptability and use of safety fuels for aircraft from the standpoint of safety and performance in aircraft engines, but insufficient data have been presented to enable any definite conclusions to be drawn. It has been stated[1] that the use of high-flash fuels would eliminate the danger of explosions due to the collection of vapors in the wings and other portions of the airplane and their ignition from a spark or a static charge. On the other hand, the danger of the formation of explosive mixtures in the fuel tanks would be greater with the lower volatility fuel than with the high-volatility fuel, since the vapor mixture formed above the high-volatility fuel would be too rich to support explosive combustion.

Characteristics of High-Flash Aviation Fuel

From the safety viewpoint very little definite information is available on the necessary characteristics of high-flash aviation fuel, but it is generally accepted that flash point and spontaneous ignition temperature are two factors intimately connected with the fire hazard and are the principal characteristics to be considered. In the case of an aircraft fire occurring after a crash, in flight, or during refueling due to a spark or flame, the flash point is the controlling factor since it indicates to a great extent the ease of formation of combustible mixtures. Where the fire starts as the result of fuel contact with hot engine parts and in the absence of a flame, the spontaneous ignition temperature of the fuel is the more important characteristic. Table 1 lists several fuel types with their spontaneous ignition temperatures.

It is interesting to note that the spontaneous ignition temperatures of the high-flash fuel types are not greatly different from those of the high-volatility fuel types of equal octane number. Therefore, from that standpoint at least, the safety fuel has no decided advantage over the high-volatility type.

The principal qualities of the high-flash fuel which influence aircraft engine performance are (1) octane number, (2) volatility, and (3) heating or combustion value. According to present trends the safety fuel must have an octane number at least equivalent to that of the higher grade of high-volatility aviation gasolines. This means that it should have an octane number around 90 to 100. The volatility must be low to ensure a relatively high flash point. This requires a different method of introducing the fuel into the engine cylinders than that used for the regular high-volatility type of fuel, if the losses in power and depreciation of octane number due to air or mixture preheating are to be eliminated. The injection systems for high-flash fuels are reported[2] to give good fuel distribution, good acceleration characteristics, and freedom from icing. Starting difficulties are encountered with low-volatility fuels, and, as a result, starting is usually effected by the use of light gasoline.

Proper combustion characteristics are as important in high-flash aviation fuel as in the regular aviation gasoline. A high heat of combustion is necessary to ensure a reasonably low specific fuel consumption.

Other general qualifications for safety fuel are the same as those for the regular aviation gasolines and consist mainly of stability toward oxidation and gum formation, low sulfur content, low freezing point, noncorrosiveness, and good lead susceptibility.

Table 2 lists the characteristics of an average type of safety fuel.

The qualities listed in Table 2 correspond to those of the higher grades of high-flash aviation fuel produced in the past five years, and, with the exception of boiling range and flash point, they are the same as required for the regular aviation gasoline. No definite specifications for an ideal safety-type aviation fuel have been agreed upon because of the lack of data on engine operation with this type of fuel. Heron and Beatty[3] give the opinion that the flash point can-

Table 1 — Spontaneous Ignition Temperatures of Various Fuels[1] and Fuel Materials

	Octane No., A.S.T.M. Motor	Flash Point °F.	I. B. P. °F.	Spontaneous ignition Temp., °F.
Paraffinic high-flash fuel, unleaded	99	110	330	930-1030
Plus 3 cc T.E.L./gal	100 + 2 cc *	110	330	990-1030
Aromatic high-flash fuel, unleaded	75	110	338	790-1030
Plus 3 cc T.E.L./gal	86	110	338	880-1030
C.P. iso-octane, unleaded	100	...	211	970-1030
Plus 3 cc T.E.L./gal	100 + 3 cc *	...	211	1060-1100
Iso-octane, straight-run blend, unleaded	85	...	...	910-1030
Plus 3 cc T.E.L./gal	100	...	...	960-1030

* Iso-octane + — cc T.E.L./gal.

*Reprinted from the section on "'Safety' or High-Flash Aviation Fuels" in the book "Aviation Gasoline Manufacture," by Matthew Van Winkle (1944), with permission of the publisher—McGraw Hill Book Co., Inc.

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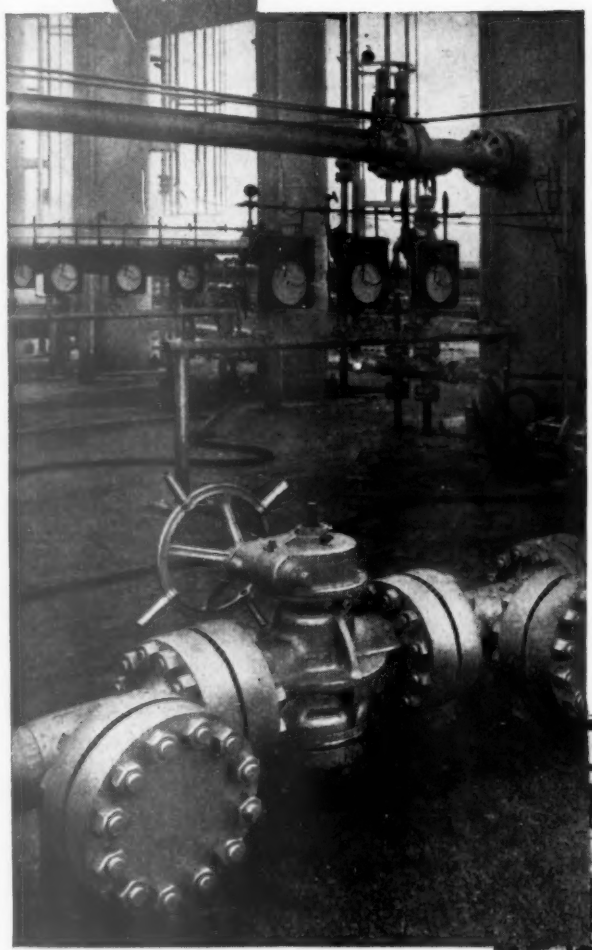

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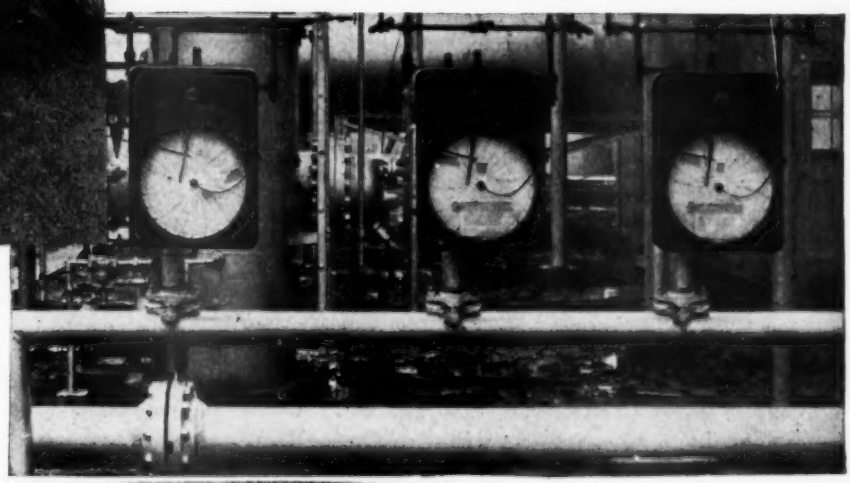

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Table 2—Characteristics of High-flash Aviation Fuels

Calorific value net, Btu/lb	18,300-18,700
Corrosion	None
Distillation, A.S.T.M.:	
I.B.P., °F., min	300-320
E.P., °F., max	400-420
Flash point, °F., min	105-110
Freezing point, °F., min	—76
Gum, accelerated, mg/100 ml, max	5.0-6.0
Gum, copper dish, mg/100 ml, max	5.0-6.0
Octane number*	90-100
Sulfur, %, max	0.05
Tetraethyl lead, cc/gal, max	3.0-4.0

* A.S.T.M.—C.F.R. Aviation method.

not be lowered below 110° F. without reducing the safety factor, nor can the end point be increased as it would cause unsatisfactory engine performance. Ellis and Sweeney[4] suggest the use of higher end-point fuels to increase the available supply.

Manufacture

Aviation safety fuels made from aromatic crude oils and by synthetic methods were used to a limited extent in Europe for several years before a fuel of this type was introduced into this country. In 1929 the Standard Oil Development Co. marketed an aromatic high-flash aviation gasoline which was made by high-temperature hydrogenation and which had an octane number of approximately 90. Until the late thirties the interest of both the aviation industry and the petroleum industry in safety fuel was mostly academic, and there was very little of this type of fuel (compared to the conventional type) manufactured and used. This apparent lack of interest was due to several factors. Although it was recognized that a fire hazard existed with the use of the high-volatility fuels, no definite steps had been taken to determine what constituted a "safe" fuel. The aviation industry was also reluctant to adopt the use of gasoline of which there was only a relatively small supply in the quality desired and whose cost was high. The petroleum industry on the other hand was not greatly interested because of the high manufacturing cost of such a fuel and the small demand.

With the advent of hydrocarbon conversion processes in petroleum refining it was found that large quantities of suitable safety fuel could be produced as a byproduct from the manufacture of high-octane aviation base stocks and from iso-octane manufacture at a lower cost, and this attracted the interest of the aviation-fuel users and producers. Because of this renewed interest within the past few years, there have been many investigations conducted by the refining industry to determine possible ways of manufacturing this type of fuel.

There are at present two principal classes of high-flash aviation fuel being produced: (1) aromatic and (2) paraffinic.

Aromatic-type safety fuels are those fuels which contain 20% or more of aromatic hydrocarbon compounds. They may be produced from selected aromatic crude oils by extraction-distillation methods, or by conversion methods from any type of crude oil. It has been estimated that over 400,000,000 gal. per year of 300 to 400° F. boiling-range aromatic safety fuel is potentially available from aromatic crude oils along and around 200,000,000 gal. yearly potentially available from cracking and reforming processes.

Some of the methods capable of producing aromatic safety fuels are listed as follows:

1—Extraction processes:
- a. Sulfur dioxide
- b. Furfural

2—Conversion processes:
- a. Catalytic aromatization—hydroforming
- b. Thermal aromatization
- c. Destructive or high-temperature hydrogenation
- d. Catalytic cracking or reforming
- e. Thermal reforming—polyforming—gas reversion

Extraction: Extraction processes utilizing solvents having a high degree of selectivity for aromatic hydrocarbons may be used to produce aromatic safety fuels. In this method selected aromatic crude oils are fractionated to secure a cut of the correct boiling range, and this cut is extracted with suitable selective solvents such as sulfur dioxide[5] and furfural, which separate the aromatic portion. The aromatic safety fuel base is then recovered from the extract, usually by distillation.

Conversion Processes: Catalytic aromatization, thermal aromatization, catalytic cracking, and thermal reforming processes are discussed in detail in Chap. V of *Aviation Gasoline Manufacture* in connection with the manufacture of high-octane aviation-fuel base stocks. The fractions boiling from 300 to 400° F. from the conversion product resulting from most of these processes make a satisfactory safety fuel. To procure higher yields of this fraction the conditions of operation of the processes must be changed somewhat.

High-temperature hydrogenation,[6] a process producing a high-octane heavy naphtha through catalytic destructive hydrogenation at high temperatures, was the first source of aviation safety fuel in this country. In this process the charging stock, usually consisting of recycle gas oils, heavy cracked naphthas, or similar materials, is subjected to temperatures of 932 to 1040° F. in the presence of a catalyst (not specified, but probably oxides or sulfides of such metals as molybdenum, tungsten, cobalt, and nickel and hydrogen) under pressures of 3000 to 5000 lb per sq. in. The resulting products (depending upon the characteristics of the charge stock and catalyst) are a highly aromatic gasoline fraction and gas composed of lighter hydrocarbons and hydrogen. The yield of gasoline ranges from 58 to 71%. One gasoline[6] produced by this method, 80% of which distilled above 212° F., had an octane number of 80 but had a very low lead susceptibility. The low lead response was due to the presence of aromatic compounds.

The yields of aromatic safety fuel available from conversion processes depend upon many factors: the type of process, the charge material, the operating conditions, and whether or not the process is operated to produce safety fuel or some other product with the safety fuel produced as a byproduct. The quality of the fuel depends largely upon its method of manufacture. Table 3 lists the characteristics of aromatic safety fuels made by several different methods.

The stocks having octane numbers from 85 to 90 may be leaded to a 90 to 95 octane number with the addition of 4 cc of T.E.L. per gal. In general, the aromatic high-flash fuels have poor lead susceptibilities and have heat values 7 to 9% lower than the paraffinic types. It is claimed that the Houdry catalytic fuel listed in Table 3 has only 1.5 to

Table 3 — Properties of Aromatic-type High-flash Aviation Fuels

	SO_2 Extraction S. Texas naphtha[5]	Houdry catalytic cracking[7]	High-temperature hydrogenation[6]	Polyforming[4]
Composition:				
Aromatics }	84.0	36	(50-75)	(20-25)
Olefins }	84.0	4		
Paraffins and naphthenes	16.0	60	...	...
Tests:				
Acid heat, °F.	...	...	...	2
Corrosion	None	None	None	None
Distillation (A.S.T.M.):				
I.B.P., °F.	247	330	309	301
10% °F.	267	341	...	311
50%, °F.	292	353	...	326
90%, °F.	337	376		372
E.P., °F.	394	397	411	426
Flash point, °F.	...	105	107	...
Gravity, A.P.I.	33.7	35.9	28.5	36.2
Gum, copper dish, mg/100 ml	...	...	4.8	...
Heat content (gross), Btu/lb (calc.)	...	19,620	...	...
Octane No. (A.S.T.M.):				
Unleaded	91.1*	76.5	93	80
Plus 1 cc T.E.L./gal	...	81.5	...	86
Plus 2 cc T.E.L./gal	...	83.5	...	87
Plus 3 cc T.E.L./gal	...	84.5	...	88
Plus 6 cc T.E.L./gal	...	86.5	...	...

* C.F.R. method

2.0% lower heating value than a similar boiling-range paraffinic safety fuel.

Suitable high-flash paraffinic-type aviation fuels cannot be obtained directly from crude oil distillation or extraction since the octane number of the paraffin compounds contained in the heavy naphthas is much too low. Therefore, the high-octane paraffinic types of high-flash fuel must be produced by conversion methods. Suitable high-octane safety fuels have been produced by catalytic alkylation and catalytic polymerization plus hydrogenation. Another possible process source is that of naphtha isomerization.

Under present conditions of operation whereby the various iso-octanes are the principal product, there is available over 50,000,000 gallons yearly of 80 to 90 octane number alkylate and hydrogenated polymer having a boiling range of 300 to 400° F. This estimate was given by Hubner[1] in 1940 and was based on the yields from the iso-octane production at that time. Production has increased greatly in the last two years, and it is probable that the potential byproduct production of paraffinic safety fuels at present or in the near future will be around 250,000,000 to 300,000,000 gallons yearly.

Conversion Methods

The two principal methods suitable for the manufacture of paraffinic safety fuel are catalytic alkylation, and selective polymerization and hydrogenation. A third possible process is naphtha isomerization. These processes are all described in detail in Chaps. V and VI of *Aviation Gasoline Manufacture* in connection with the manufacture of the conventional high-volatility aviation fuels.

In the alkylation process the formation of iso-octanes is accompanied by the formation of isododecanes, and the yield of heavy alkylate usually amounts to 10 to 15% of the total alkylate produced. This isododecane fraction boils between 300 and 400° F. and has an octane number ranging from 80 to 95, depending upon the molecular configuration.

Catalytic polymerization also produces 12-carbon-atom olefin polymers which when hydrogenated have suitable boiling ranges and octane numbers of 85 to 95. The yield of this material based upon the total polymer is around 10 to 15%.

No data have been published on the catalytic isomerization processes for naphtha in regard to their application to safety fuel manufacture, but it is probable that a considerable yield of high-flash paraffinic aviation fuel could be produced which would have a high unleaded octane number and good lead susceptibility.

It should be remembered that the yields given above are those for the byproduct manufacture of the safety-fuel fraction. It is entirely possible, should the economic picture change in regard to general acceptance of this type of fuel, that the processes could be changed to the manufacture of the higher boiling high-flash aviation fuel, and the present yields of this material and the yields of iso-octane fraction probably could be reversed.

Another possibility for the manufacture of larger quantities of high-octane safety fuels is that of blending high-octane hydrocarbons having the required volatility characteristics with stocks of lower octane number having good lead susceptibilities, and raising the octane number of the blend to the necessary value by the addition of tetraethyl lead. This procedure is comparable to that followed in the manufacture of high-octane high-volatility aviation gasolines and offers a method of reducing costs and increasing volume.

Table 4 shows the lead susceptibility of a hydrogenated tri-isobutene-straight-run blend.

Table 5 lists the characteristics of some typical paraffinic high-flash aviation fuels produced by different processes.

In general, the paraffinic high-flash safety fuels have octane numbers from 80 to 100 and the lead susceptibilities are high enough to enable the lower octane stocks to be raised to 95 to 100 octane number by the addition of 4 cc of tetraethyl lead per gallon. These fuels are stable, are low in sulfur content, and have high heats of combustion.

Performance

High-flash fuels are difficult to vaporize and therefore are not satisfactory for use in regular carbureted motors. With the use of injection systems it is believed that such fuels will perform equally as well or better than the high-volatility fuels of equivalent octane number. Starting difficulties will be a factor in the use of high-flash fuels, but these may be overcome by the use of an accessory starting fuel. One hundred octane high-flash fuels are said to give the same power output as is given by iso-octane when injection is used for both fuels.

Table 4

Lead Susceptibility of 50:50 Blend of Straight-run Naphtha and Hydrogenated Tri-isobutene

	Octane No. (A.S.T.M. Motor)
Unleaded	84.0
Plus 1 cc T.E.L./gal	90.5
Plus 3 cc T.E.L./gal	96.0

Future

Although high-flash or safety aviation fuel has been available in this country since 1929, it has not achieved a position of prime importance in the aviation-fuel picture. Its widespread use has been objected to on such grounds as high cost, insufficient quantities available, starting difficulties, questionable performance in existing-type motors, and the questionable degree of safety attained by its use. As a result no definite requirements have been established for such fuels. It is possible that, if an agreement is reached, primarily among users of aviation fuels, as to what constitutes a "safety" fuel, and these specifications are given to the petroleum industry, that industry will be able to supply all the fuel necessary for their requirements at a cost comparable to the equivalent grade of high-volatility aviation gasoline.

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Table 5—Properties of Paraffinic-type High-flash Aviation Fuels

	Straight-run[1]	U.O.P. polymerization hydrogenation[1] 1°	2°°	Isodo-decane[1]	Hydro-genated tri-iso-butene[1]	Alkylate[1]
Acid heat, °F.	...	...	...	...	...	2
Distillation (A.S.T.M.):						
I.B.P., °F.	332	273	250	342	349	310
10%, °F.	340	317	281	...	...	327
50% °F.	350	389	361	...	...	343
90% °F.	375	389	361			362
E.P., °F.	400	450	390	342	350	384
Flash point, °F.	...	...	...	...	...	103
Gravity, A.P.I.	37.9	50.5	58.1	55.7	58.3	57.0
Gum, accelerated, mg/100 cc	...	...	...	...	...	2
Octane No. (A.S.T.M. Motor):						
Unleaded	68.5	89	96	100	100	81
Plus 1 cc T.E.L./gal	74.5	...	...	...	...	86
Plus 2 cc T.E.L./gal	79.0	...	...	...	...	89
Plus 3 cc T.E.L./gal	81.0	...	...	...	...	92
Plus 4 cc T.E.L./gal	82.5	...	...	...	...	94

° 1 part isobutene to 2 parts n-butene.
°° 4 parts isobutene to 1 part n-butene.

INFRARED SPECTROSCOPY

New Analytical Tool for New Processes

By D. P. Thornton, Jr.

INFRARED spectroscopy is one of the newest analytical tools developed as an aid in petroleum hydrocarbon research and in analysis for refinery process control. A number of oil companies now are using the method among them Shell Oil Co. and Socony-Vacuum Oil Co., Inc. While infrared spectrometry is "new" to the oil industry, and indeed to industry at large, the fact that many chemical compounds will absorb specific wave lengths of infrared radiation, the basic principle of this method of analysis, has long been known to science. One of the early investigators of infrared absorption spectra was Coblenz[1], whose work was published in 1905, while Lecomte and Lambert[2] in France were among the first to apply the method to the analysis of hydrocarbon mixtures. Barnes, Liddel, Williams[3] and Wright[4] were among the first to develop comprehensive methods of analysis suited to industrial requirements in this country, as well as much of the required instrumentation.

Analysis by infrared spectroscopy has one advantage few other methods possess. The sample is in no way changed by the analysis (very advantageous with rare or valuable samples) nor is it likely to become contaminated by reagents and foreign materials or damaged by heating and cooling. Other physical properties of the sample—boiling or freezing point, vapor pressure, solution in solvents, refractive index, etc.—have no bearing on its infrared spectrum. Even compounds so highly colored as to be opaque to the radiations have been examined with reflected infrared light: depositing the sample in thin films, or dispersing it in a solvent which will not absorb (interfere) in the region to be studied.

New Analytical Problems

Most analytical methods for hydrocarbon analysis have shown themselves to be unsuited in some manner for present day process demands. The oil industry's entry into the field of chemical manufacture to produce aviation gasoline components, explosives and synthetic rubber components, as well as chemicals and solvent specialties, has brought into use such processes as isomerization (of butanes, pentanes and hexanes) alkylation, de-alkylation, aromatization and polymerization, to name a few. All these present new analytical problems.

Many of the older methods of analysis, regardless of relative degree of accuracy, are time-consuming. Sometimes a period of many hours is required between the drawing of samples and the final result. On the other hand, most of the new processes are sensitive to fluctuations in feed-composition and catalyst-activity. They require frequent product analyses for economical process control. Also because many of the new products have boiling points close to other and perhaps undesirable compounds, fractional distillation methods as well as many of the older chemical methods do not supply the necessary degree of accuracy.

It is recognized that infrared spectrophotometric analysis is not the panacea for analytical troubles long sought by technologists in the petroleum and other industries. The method is not expected to supplant or outmode other established analytical procedures. Rather, it should be regarded as a supplementary tool which adds another physical measurement for use in describing either a single chemical compound or a mixture of several compounds which may or may not be chemically similar. One of the best known analytical methods, precise fractional distillation, still will be needed if infrared spectroscopy is used for final analysis, because its speed and accuracy are enhanced if the mixture to be analyzed contains only three or four components.

Many "unknowns" encountered are mixtures of a very large number of components. Before analysis they must be split by distillation or other procedures into fractions having not more than seven components, and preferably four, for convenient handling.

As an example of the problems being

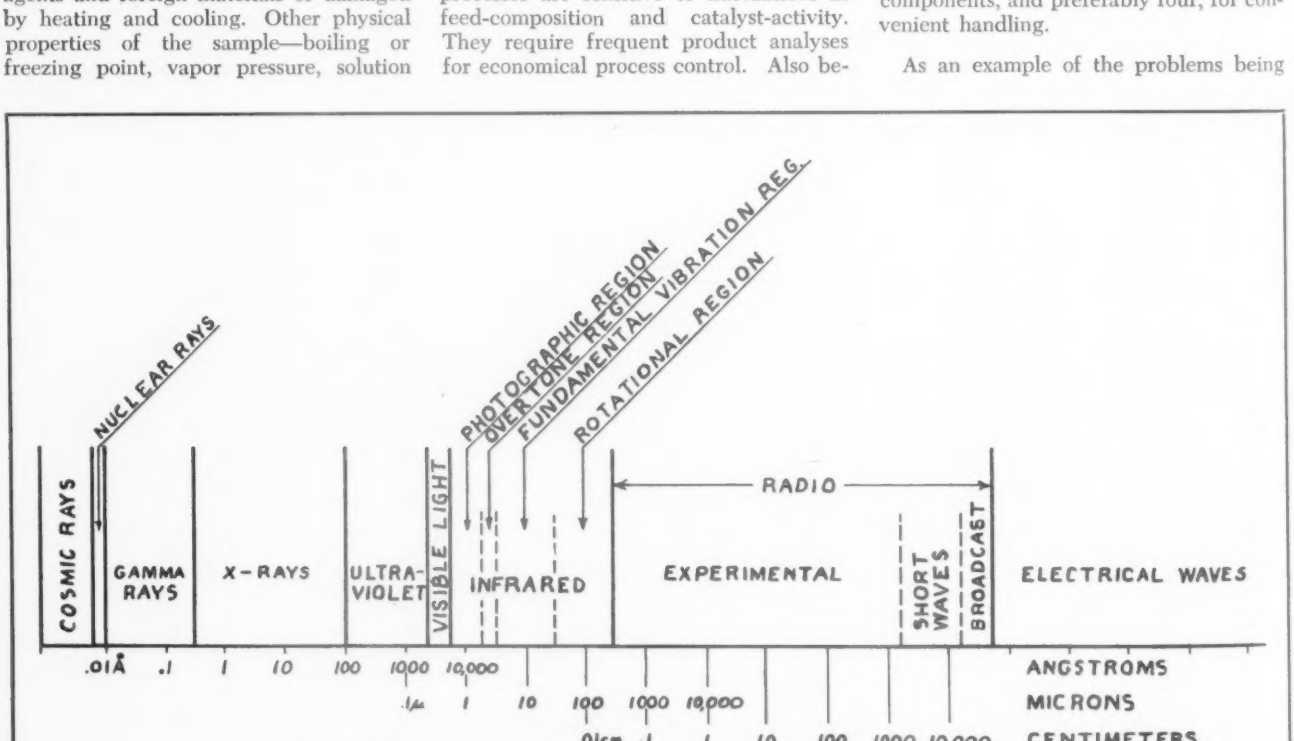

Fig. 1—Schematic diagram of part of the electromagnetic spectrum

encountered with new processes, the petroleum industry now is manufacturing butadiene by catalytic dehydrogenation of the three butenes: butene-1 and *cis* and *trans* butene-2 with boiling points of 23.0°F., 33.8°F. and 36.5°F., respectively. Impurities in the refinery "B-B" cut used as raw feed stock may include isobutylene (b.p. 21.2°F.), butane (b.p. 31.1°F.) and isobutane (b.p. 13.64°F.). A fractional distillation analysis of this mixture would be difficult and long drawn-out because of the closely-grouped boiling points. Accuracy of results might be questionable for some components.

However, this 6-component mixture can be easily split into two or more fractions by preliminary fractional distillation before analysis by infrared spectrophotometer. The two stereoisomers, *cis* and *trans* butene-2, while boiling only 2.7°F. apart, and butene-1 and isobutylene, boiling within 1.8°F. of each other, are readily identified quantitatively by their infrared absorption spectra. Families of hydrocarbons, without reference to molecular weight of individual homologues present, generally can be detected, almost at a glance by this method.[3]

The method of infrared spectroscopy as has been stated above, depends upon the absorption of specific wave lengths of infrared radiation by a compound or mixture. The measurement consists in determining how much of the radiation at a given wave length is absorbed by the sample in question. A schematic diagram of the complete electromagnetic spectrum, of which visible light, ultra violet and infrared radiation, as well as radio and X-rays form a part, is shown in Fig. 1.

Instrument 'Bottlenecks'

The infrared portion of the spectrum will be seen to extend from the long wave length limit of sensitivity of the human eye, 7500 Angstrom units (0.75 micron*) to about 350,000°A. (350μ), the region of the ultra-short radio waves. The various subdivisions of the infrared region are shown by dotted lines in Fig. 1, and are: the photographic region from 0.75μ to 1.3μ; the overtone region from 1.3μ to 2.5μ; the fundamental vibration region from 2.5μ to about 25μ, and the rotational region from 25μ to 350μ. While each of these regions is important, interest generally centers about the fundamental vibration region. Because of the limitations of sources of radiation as well as prism and lens materials, only a portion of the fundamental vibration region (2.5μ to 15μ) has been the most thoroughly investigated.

Roughly speaking, an infrared spectrophotometer consists of a radiation source, a dispersing means to spread out this radiation in order to provide narrow wave length bands at accurately-known wave length positions, means of interposing a sample of suitable thickness into the path of this radiation, and a detector and amplifier to measure accurately the intensity of radiation in each narrow band. Indicative of the problems that have confronted experimenters is the fact that only recently has a commercially standardized research-type instrument been in process of manufacture. An instrument devised for limited routine-type work became commercially available on high priority a little more than a year ago. The research instrument probably will sell for approximately $10,000, while the makes of routine instruments now on the market are priced in the neighborhood of $3,000. Methods of reporting and computing results likewise have varied widely among the limited discussions in the literature.

Possibilities Recognized

As has been previously mentioned, the possibilities inherent in infrared spectroscopy have been long recognized. However, limitations in materials required for prisms and lenses, as well as difficulties in reproducibly quantitative measurement of the unabsorbed radiation have been the principal stumbling blocks in the way of successful utilization of the method.

Prisms and cell windows must be made of materials which do not absorb infrared in the frequency region being used. Generally these now are made of sodium chloride (rocksalt), potassium bromide or lithium fluoride; all of which require protection from water-vapor and careful handling. Gratings, ruled on any convenient material, theoretically can be substituted for prisms, but since they produce several different orders of spectra which generally overlap in this region, their use is undesirable from a practical standpoint.

The energy measuring device must be sensitive and therefore delicate. The radiation cannot be photographed at wave lengths longer than 1.2μ, is undetectable by photocells above 1.7μ. Thus the most commonly used detectors are bolometers, thermocouples or perhaps, radiometers. Since the devices must detect temperature changes within a limit of error of 0.00005°C.[3], the output voltage from a thermocouple is small (about 1 microvolt, or 10^{-6} volt) and not readily susceptible to electronic amplification. Bolometer output, though similarly minute, may be electronically amplified, but there are circuit complications here also. Authorities still differ over the relative merits of bolometers and thermocouples. At present both are in use for research-type instruments while routine instruments generally are equipped with thermocouples and sensitive galvanometers.

Some of the difficulties encountered with natural crystals of sodium chloride, potassium bromide and lithium fluoride were in finding flawless samples large enough to permit reasonable sized prisms to be cut from them. The prisms must have sufficient "aperture" (effective light-handling capacity) to pass enough infrared radiation to permit readable and reproducible registration on thermocouple or bolometer. Kremer[5] of the Harshaw Chemical Co. at Cleveland, has described a method of "growing" large crystal "synthetic" prisms of about 6 in. by 6 in. and 4 in. thick.

Fig. 2 shows the routine-type 2 to 14.5μ range instrument with accessories as furnished by National Technical Laboratories. These accessories include the gas-handling burettes, pressure manometer and desiccating system. The whole is mounted on a table (except for measuring galvanometer). It sells for $3750 f.o.b. factory.

Fig. 3A shows the spectrophotometer with cover removed, indicating the arrangement of the internal mechanism. Fig. 3B shows the galvanometer (enclosed, in Fig. 2, behind the wood panel at upper right of the picture) in its vibration-dampening mounting. Scale for measuring galvanometer deflections is mounted on the table as shown in Fig. 2.

Fig. 4 is a light-path diagram of the instrument, arranged to appear in the same sequence of arrangement of apparatus as shown in Fig 3A.

Instrument Described

Essentially, a routine-type instrument contains the same working parts as the wider ranged research instrument. For simplicity, a routine-type instrument will be described as pictured in Figs. 3A and 4.

Radiation is supplied from the Nernst Glower, 1, enclosed in a water-jacketed housing (shown disassembled in Fig 3A, upper left center). Unfiltered radiation enters the totally-enclosed instrument through the water-cooled metal shutter and diaphragm, 2, which regulates the energy entering the instrument, and the rock salt window, 3. Behind the window are a filter, 4, used to absorb visible radiation, and a lithium fluoride shutter, 5, the latter being used when the instrument is operated at long wave lengths. Radiation entering the window is reflected and focused by the spherical mirror, 6, through the absorption cell, 7, containing the sample (in Fig. 3A the cell is partly obscured by the slit-adjusting mechanism).

Attached to the cell is the frame of the first or entrance slit, 8; its width is adjustable between 0.01 and 2.0 mm. The sides of this slit are curved, compensating for image distortion in the prism. The flat mirror, 9, reflects the unabsorbed radiation onto the off-axis (14°) Littrow-type (parabolic) collimating mirror, 10, which in turn reflects the now-parallel pencils of radiation into the 60° rock salt prism, 11. Radiation traversing the dispersing prism is reflected almost back

*1 micron (μ) = 0.001 mm.

on itself by the flat mirror, 12, actually traversing the prism, 11, twice. The size of the two mirrors, 9 and 10, with the prism, 11, effectively determine the aperture of the instrument, which in this case is about f6.

Re-refracted (dispersed) radiation from the prism, 11, is again reflected by the Littrow mirror, 10, this time directly to the exit or second slit, 13 (straight-edged). This slit forms the actual "spectral image" for analysis. The spectrum thus formed at 13 is concentrated on the receiving junctions of the vacuum thermopile, 15, by means of the parabolic mirror, 14, and the rock salt lens, 18. Electrical connections at the thermopile, 15, convey the electric energy generated by the thermopile to the measuring galvanometer (not shown) which is of the ballistic type. The angular setting of the prism, which, of course, controls the wave length of the radiation reaching the thermopile, is made through the lever- or tangent-arm, 16, resting on the turret assembly, 17. The turret assembly, as shown more clearly in Fig. 3A (lower right), consists of 18 pins of varying length, each used for setting the instrument to a specific wave length. The pins themselves are capable of adjustment during calibration of the instrument.

As stated, this instrument is intended only for routine analyses by determination of absorption at certain wave length (s). However, it may be converted to a continuous-spectrum instrument by substituting a calibrated micrometer for the turret assembly. Or, a cam could be substituted instead, and the whole driven by a constant-speed motor. The optical system can be converted for over-all spectral coverage by substitution of the appropriate crystalline materials for that furnished in window, lens and prism.

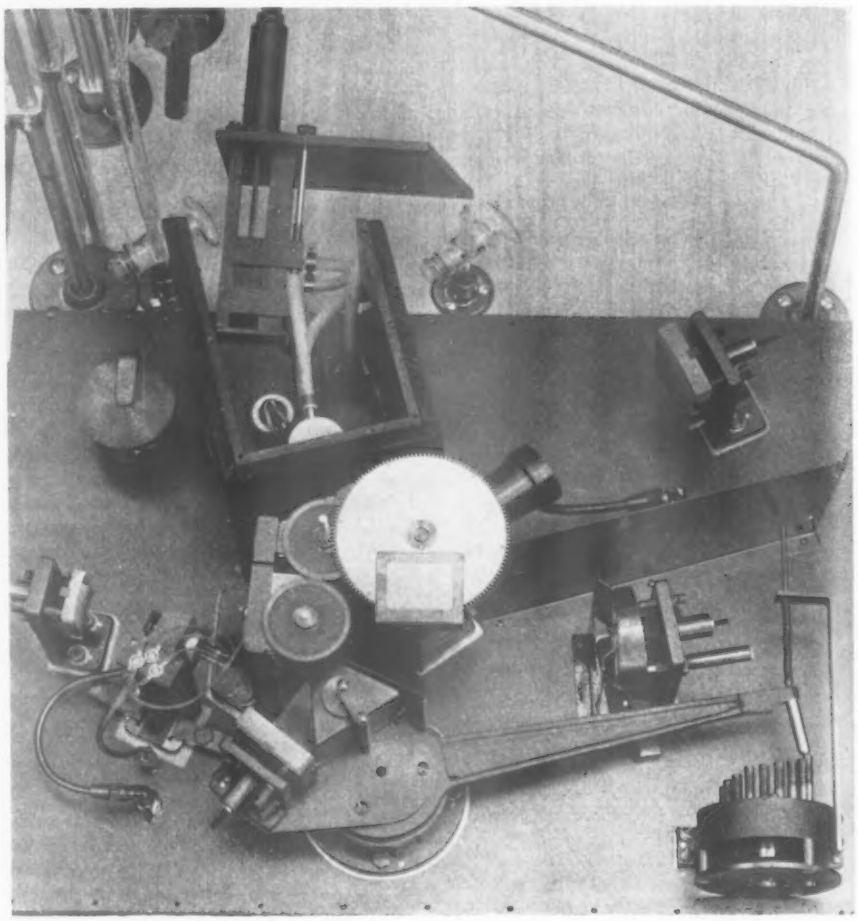

Fig. 3A—Infrared spectrophotometer with cover removed

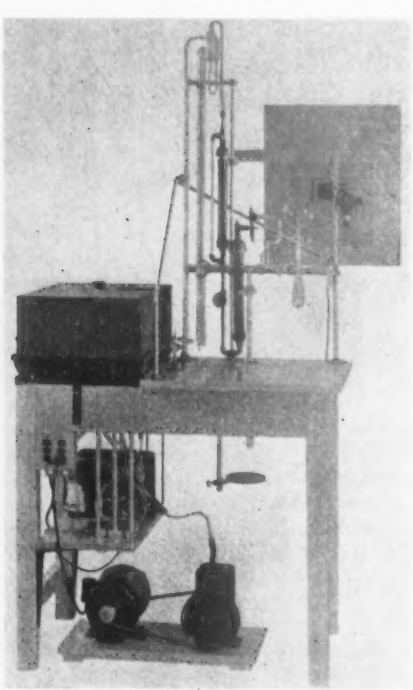

Fig. 2—Complete unit for routine infrared spectrophotometric analysis of hydrocarbons within the range 2.0 and 14.5μ. Left is the spectrophotometer, center, the gas handling apparatus, and right, the galvanometer and housing (separately-mounted from the table). Vacuum pump below table is connected to the thermopile, which measures the unabsorbed radiation

In some types of research instruments, the Littrow mirror is driven instead of the prism; this has the same effect of causing the spectrum to sweep across the exit slit as if the prism were moved. Also, two galvanometers generally are used, as well as photocells, and the final absorption spectrum drawn by a recording galvanometer on photographic paper. An instrument of this type is described by Barnes, et al[3], and is similar to the instruments used by Nielsen[6], Wright[4] and others.

Use of Infrared Spectra

Fig. 5 shows the complete infrared spectra of pure normal- and iso-butane in gaseous phase at two different concentrations (pressures), plotted as per cent transmission vs. wave length in microns (wave-number is shown in upper scale for convenience). The two sets of spectra are oriented with respect to each other so that wave lengths (or wave-numbers) coincide. These have been computed from the tracings produced by the instrument itself and are corrected for instrument anomalies caused from background radiation, changes in source intensity and cell condition, galvanometer drift, etc. In order

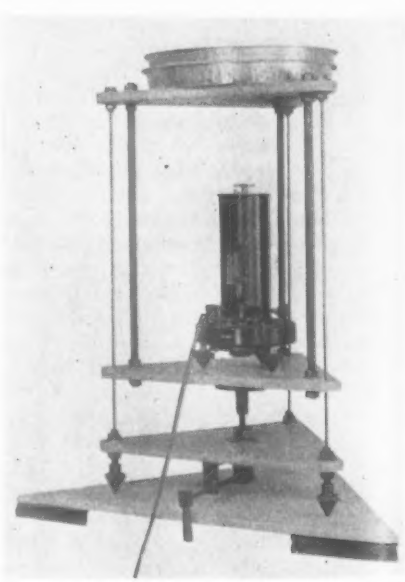

Fig. 3B—Measuring galvanometer, of ballistic type, in its vibration-absorbing mounting

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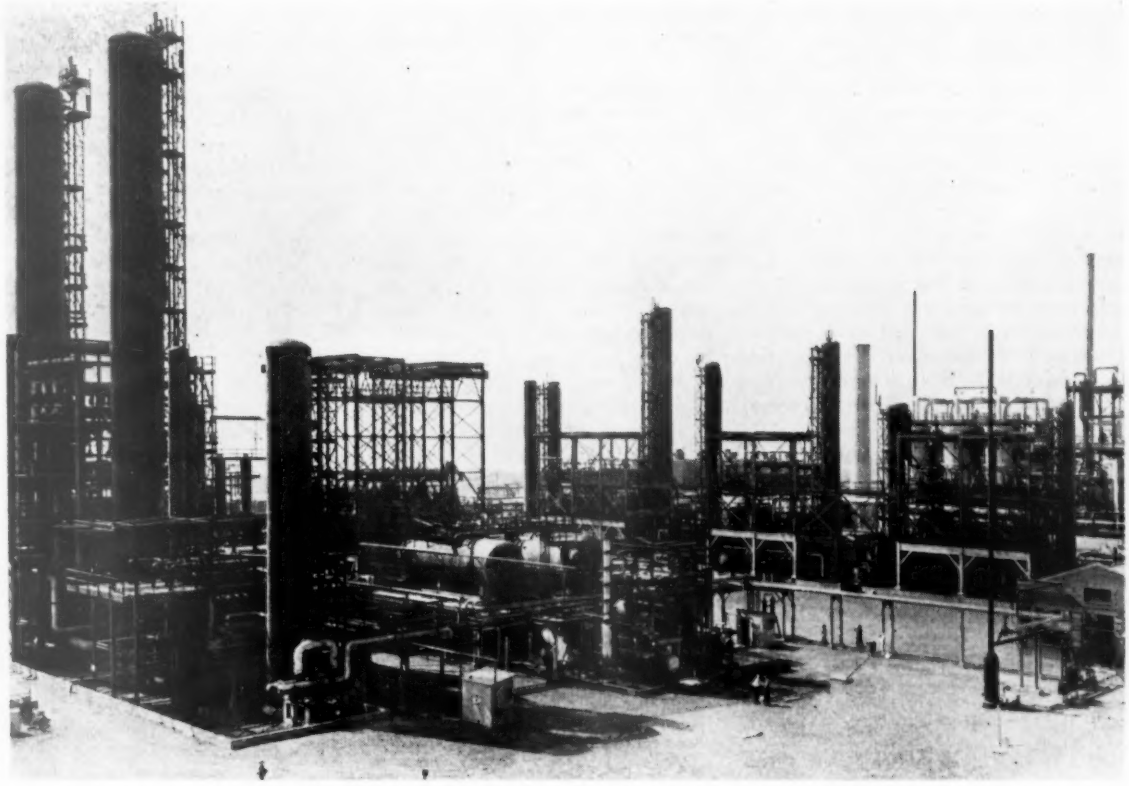

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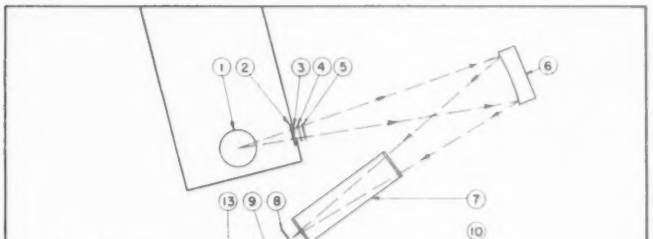

Fig. 4—Light-path diagram of spectrophotometer (see text)

to calibrate the instrument, it is necessary to have very pure reference compounds—or compounds in which the amount and nature of impurities are accurately known. (This fact gives added value to A.P.I. Research Projects and individual projects aimed at producing pure compounds for investigation of physical properties.—Ed.) From such compounds, libraries of spectra are built up, and from such comparisons as above, qualitative determinations of components in an unknown mixture are made.

Further information is desirable from complete spectra, such as determination of space configuration of the molecule, evidence of unsaturation and cyclical structure. For instance, all olefins absorb at 6.10μ, all normal paraffins at 3.5μ, while all acetylenes have a strong absorption band at 4.47μ. Carbon dioxide and water must be excluded from the sample as well as the instrument, because, unfortunately, both absorb at many wave lengths and unduly complicate the analysis.

In routine identifications and qualitative determinations, it is neither necessary nor desirable to scan the entire spectrum of any component or of the mixture itself after qualitative determination of components has once been made. Rather, the spectrum is investigated at from one to a dozen specific wave lengths, depending on the complexity of the mixture. Referring to Fig. 5, it will be noted that there are at least 4 points where maximum absorption of infrared exists in one of the pairs of spectra while minima exist in the other pair. For example, on the (b) spectra of the two compounds near 13.3μ, butane shows 10% transmission while isobutane transmits over 90% of the radiation. Near 11.1μ a similar situation exists again. This is true to a lesser extent at 8.6μ and to a still lesser extent between 8.5 and 7.6μ. These might be selected by the analyst as check points—comparing data from two or three such points for accuracy or to determine an average, perhaps. The transmission band between 2 and 4μ would not be used, for absorption here is characteristic of hydrocarbons in general and for the paraffin family in particular.

If the mixture to be analyzed was known to contain but the two components, a "spot check" of transmission at any of the 4 points would give infrared absorption value due to but one of the two components.

The analyst first would construct a "working curve", similar to that shown in Fig. 6 for mixtures of isobutane in normal butane, of "extinctions" ($\log_{10}$ of the fraction: observed intensity with cell and sample in radiation path—I_o—divided by intensity with empty cell in radiation path—I) vs. corresponding concentrations of the minor constituent in the major constituent at one or more of those specific wave lengths selected for "spot check." Then, having determined extinction (per cent transmission is used by some workers) of a specific unknown sample at that check point, the concentration of the minor constituent would be read from the curve. In Fig. 6, an extinction of 0.3 indicates approximately 4.8% isobutane impurity in normal butane; the curve given is, however, merely an example and not drawn from actual data.

Alternative Method

An alternative method would be to set up a system of simultaneous equations of the form developed by Nielsen and Smith[6] for mixtures obeying Beer's law:

$$E = (e_o c_o + e_1 c_1 + e_2 c_2 \ldots) l \text{ K},$$

in which E is "extinction" for the wave length used, i.e., log (I_o/I) where I_o is the intensity of the incident light and

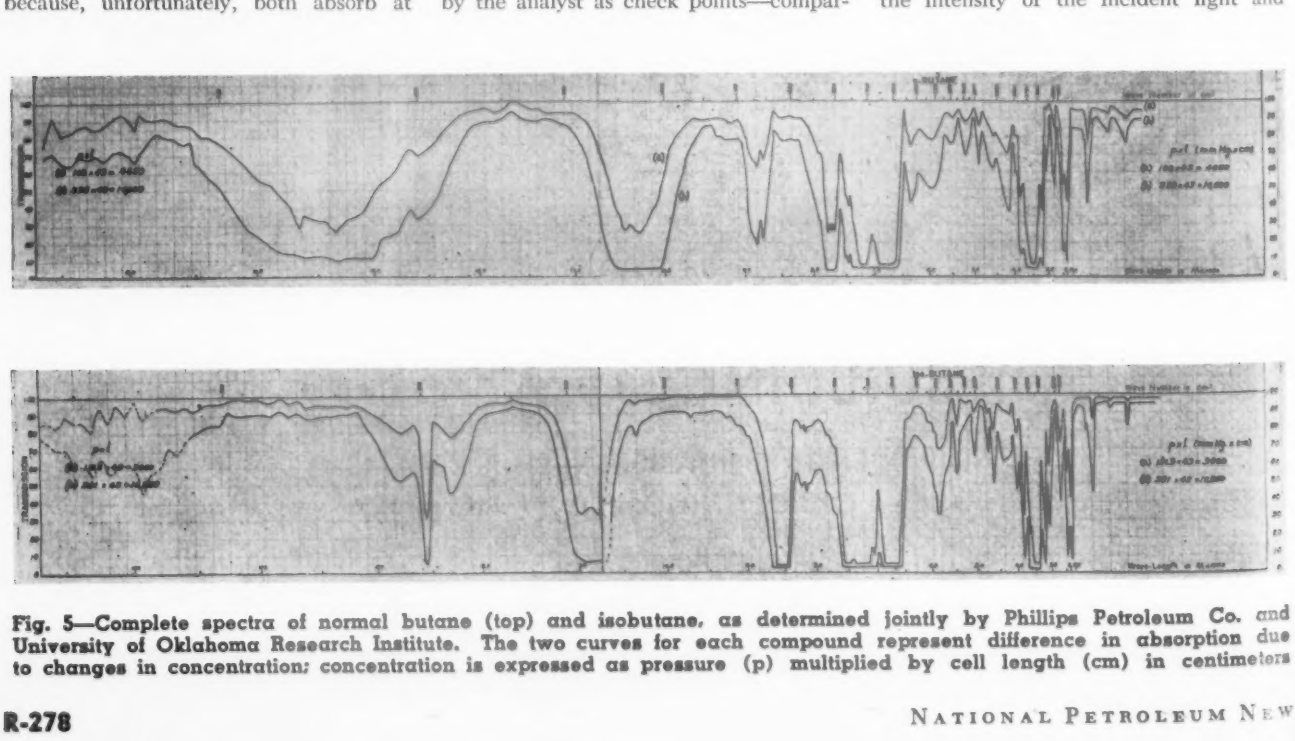

Fig. 5—Complete spectra of normal butane (top) and isobutane, as determined jointly by Phillips Petroleum Co. and University of Oklahoma Research Institute. The two curves for each compound represent difference in absorption due to changes in concentration; concentration is expressed as pressure (p) multiplied by cell length (cm) in centimeters

I is the intensity of the transmitted light; c_0, c_1, c_2, ... are the concentrations of individual components of the mixture; e_0, e_1, e_2, ... are their extinction coefficients, l is the length of the light path through the cell, and K is a cell constant, depending largely on the nature and condition of the windows of the cell for its value.

The method of simultaneous equations, required for analysis of multicomponent mixtures, places obvious limitations on the number of such components for which simultaneous equations can be written and solved either by a system of determinants or by matrix algebra. In addition, more than 3 or 4 components, with their possibly equally different absorptions for any given wave length of radiation, may enormously complicate the selection of "check points" for a routine analysis.

It is possible, however, to develop short cuts in avoiding necessity of solving complex systems of simultaneous equations. These depend on the nature of components in the mixture, their number, and the degree of accuracy desired in the results. Such solutions usually are based on the initial assumption that only one component, "A" is absorbing at a given wave length, then correcting this assumption later, based on fact that spot check at another frequency may reveal component "B" with some slight absorption at the check-point originally used to determine concentration of component "A". Such a method can be carried to any degree of refinement, depending on accuracy required.

Industrial Applications

There are numerous examples of the industrial use of infrared spectrophotometry, both in the literature and as described to the writer during recent visits to several oil company and other research laboratories. Unfortunately, some of the applications are connected with manufacture of war-products and cannot be discussed. Wright[4] reports that Dow Chemical Co. is using at least one instrument on 24 hours a day continuous duty, recording the analysis of a hydrocarbon gas stream and automatically controlling a distillation process. Brattain[7] and others[8] report Shell Oil Co. using infrared spectra as a method for routine control analysis of normal and isobutane mixtures in most of its refineries; the method is being extended through continued research study. Brattain[7] states:

"The routine infrared analysis of n-butane-isobutane mixtures is made as follows:

"The energy traversing the instrument and composed of the spectral interval from 1217 to 1153 cm.$^{-1}$, is read both with and without the sample in the light path. From these readings, the percentage of energy transmitted by the sample is calculated. The isobutane content (in per cent) is then read from a calibration curve. The calibration curve is plotted from readings taken on synthetic samples whose compositions are accurately known.

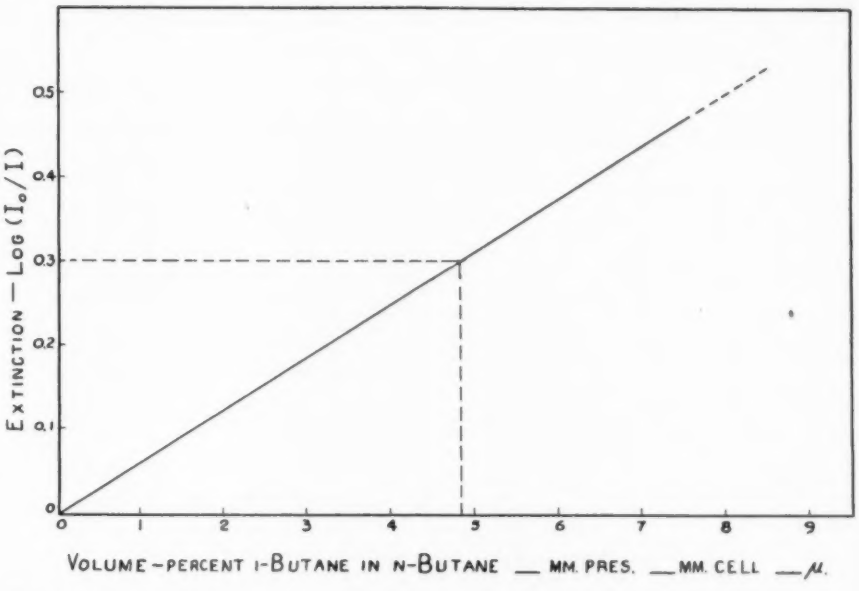

Fig. 6—Schematic diagram of a "working curve" for small amounts of isobutane in normal butane. Such a curve is developed by measuring absorption of infrared by synthetic samples containing known amounts of isobutane in pure butane with the same wave length of radiation (i.e. a "spot check")

"This system was used at the Shell Development Laboratories to analyze 5500 samples in 22 months. In addition, two special instruments using this analysis procedure are now being used for plant-control work. The accuracy of these routine analyses is about 0.5% of the total sample. The accuracy is slightly better for samples low in isobutane and slightly worse if the isobutane content is above 85%. The time required for analysis is 20 minutes per sample. This figure includes time spent turning the instrument on and off, preparing samples, calculating the results, periodically checking the method and making out analysis reports. It was arrived at by dividing the total time spent on these analyses by the total number (5500) of samples analyzed.

"The time is 15 minutes or less per sample if the number of analyses is sufficient to require 8 hours continuous work by an experienced operator. The average time per sample was increased to 20 minutes because 6 operators were trained within 22 months with the spectrophotometer seldom in operation for more than 4 hours per day. One operator analyzed 38 samples in 6 hours, including calculations and other operations incidental to the actual analyses."

Another practical example of the instrument's industrial application is to determine which of several commercial processes produces a given product in the purest possible form. A corollary to this problem is the adjustment of conditions of manufacture to produce a desired product of highest purity. The infrared spectrophotometer has given the answer to such actual problems in as little as 5 minutes. Still another problem recently solved was a job of trouble-shooting. A product had long been used for a certain purpose but recently received supplies failed to give desired results. Analysis by ordinary means revealed the most recent shipment apparently was identical with former satisfactory shipments. Obviously there was some unrecognized change which did not affect the product's ability to meet specifications but did affect its performance in use. In one such case, comparison of the infrared spectrum of a "satisfactory" sample with that of the "unsatisfactory" sample revealed the presence of an impurity that was responsible for the trouble. Check of the product during manufacture, by infrared spectrophotometer, aided in the elimination of the undesirable impurity.

Application in Refining Processes

There are numerous ways in which infrared spectroscopy may be applied to existing processes used by refiners and natural gasoline manufacturers.

Consider an HF alkylation plant. First, the alkylate charge stock preparation presents control opportunities in the isolation of isobutane and iso- and normal butylenes. That is, by infrared spectrophotometer, the overhead and bottom streams from the fractionator would be checked to determine the impurities in the isobutane overhead stream and to see if there was any isobutane in the bottoms. A similar procedure would be involved for the butylenes.

General practice now is to mix the

paraffin-olefin stream with the catalyst acid in an alkylation contactor, according to several authorities[9, 10] or at least the catalyst must not be mixed with the undiluted olefin if unwanted polymerization is to be avoided, and a considerable excess of paraffin over olefin is preferable[9]. Infrared-spectrophotometric analysis could be used to control paraffin-olefin ratio. Similarly, analysis of overhead and bottoms streams on deisobutanizer, depropanizer, debutanizer and alkylate rerun towers would indicate appropriate control needs and product purity. Analysis of light alkylate might indicate presence of organic fluorides, or this determination could be made for streams from the HF stripper, bauxite treater, or both.

Training Instrument Operators

Despite the complex and abstruse physical theories on which the infrared spectrophotometer is based, users say there is no necessity to have a staff of trained physicists as operators. Nielsen[11] reports routine infrared analyses of n-butane-isobutane mixtures in two oil company laboratories by high-school graduates. Laboratory time of 15 minutes with a precision of 0.5% is given.

One company has this to say concerning qualifications for its infrared analysts:

"The operator must receive sufficient training, and have sufficient native 'horse sense' to realize when things are going apparently wrong, and report it to someone else, well trained scholastically in the particular technique, so that impossible or erroneous results will not be certified to the plant operators. Such a situation might result in a costly mistake all around. Naturally, if the operator is doing the same thing day after day, he will have a 'hunch' when things are departing from the accustomed, such as in the following example:

"Suppose you have a control instrument set up, determining the concentration of one component by a two-spot spectral transmission. Call this component 'A'. Now assume that a small quantity of another component, 'B' which normally is not present, enters the stream. Assume further that 'B' shows some absorption of infrared at both the two frequences used for analysis. The absorption value at the two points being examined thus is increased due to the presence of the unexpected contaminant 'B', perhaps seriously affecting the accuracy of the determination. However, if the operator has sufficient intelligence to become suspicious when concentration of 'A' becomes abnormally high, he will report the anomaly to his superior. The superior, in turn, will know how to determine what is wrong and give plant operators directions for correcting the trouble. Or, in the event something has gone wrong with the instrument itself (such as damaged source of radiation, failure in the galvanometer or other registering circuit, and the like), steps can be taken toward appropriate repair or replacement."

Consensus of opinion among users now is that operators of the high-school graduate level can be used to perform satisfactorily the analyses and do the calculating on routine work. They point out, however, it will be necessary to have at least one person available who has been thoroughly grounded in the operation of the instrument and the analytical techniques to be employed. They add that a person well grounded in physics and chemistry will be required where use of the instrument in research is contemplated.

In this connection, several authorities have suggested that one of the greatest advances needed in modern instrumentation, be it spectral analysis or flowmeters and temperature and pressure controllers, is for manufacturers and users of such instruments to co-operate in developing training schools for operators as well as maintenance and repair crews. Some reports indicate this now is being seriously considered by certain manufacturers.

New Industrial Applications

It is probable that continued research will develop unexpected applications for this "new" analytical tool. An ever-increasing list of oil companies are investigating possibilities of infrared spectrophotometry, while installations of research-type instruments is definitely on the increase. The University of Oklahoma Research Institute has been one of the foremost investigators of infrared phenomena, under the direction of Physics Professor J. Rud Nielsen. One of the few research-type instruments now in this country is in daily use at its laboratories at Norman, Okla., for solving problems in connection with the war effort. A notable amount of work has been done by the research laboratories of The Dow Chemical Co., Midland, Mich., American Cyanamid Co. at Stamford[3], and of Shell Oil Co. at Houston, Texas and Emeryville, Calif. The number of research-type instruments now built or building probably exceeds 25 or 30.

Future of The Method

For the future of the method Barnes et al[3] states:

"The initial phase of infrared spectroscopy in industry was exploratory in nature. It has been known for many years that correlations could be made between observed spectral characteristics and the molecular structure of the material being studied. The fact that an infrared absorption spectrum is a unique characteristic of a compound had suggested that this spectral region could be useful for identification analysis of unknown materials and mixtures. Starting with this basic knowledge, spectroscopists in those companies which have shown an interest in the field have had to construct their own spectrometers, build up a reference library of absorption spectra of pure materials, establish structural correlations, and develop their own methods of quantitative analysis. Not only has this fundamental work been done, but also sufficient preliminary applications and results have been derived to prove conclusively that infrared pays its own way and is rapidly becoming a practical necessity to any research or production organization handling organic chemicals.

"Industrial infrared spectroscopy is now entering its second phase—the development from proving potentialities under ideal research conditions to widespread applications under any practical conditions which might occur. This expansion does not imply that all efforts must be bent toward making infrared techniques routine but it does imply that the basis upon which infrared research is conducted has been changed. It has passed the state of hiring a trained infrared spectroscopist with the general instruction that he should build an instrument and then proceed to demonstrate its utility. Neither sufficient time nor trained personnel is available to permit such an approach."

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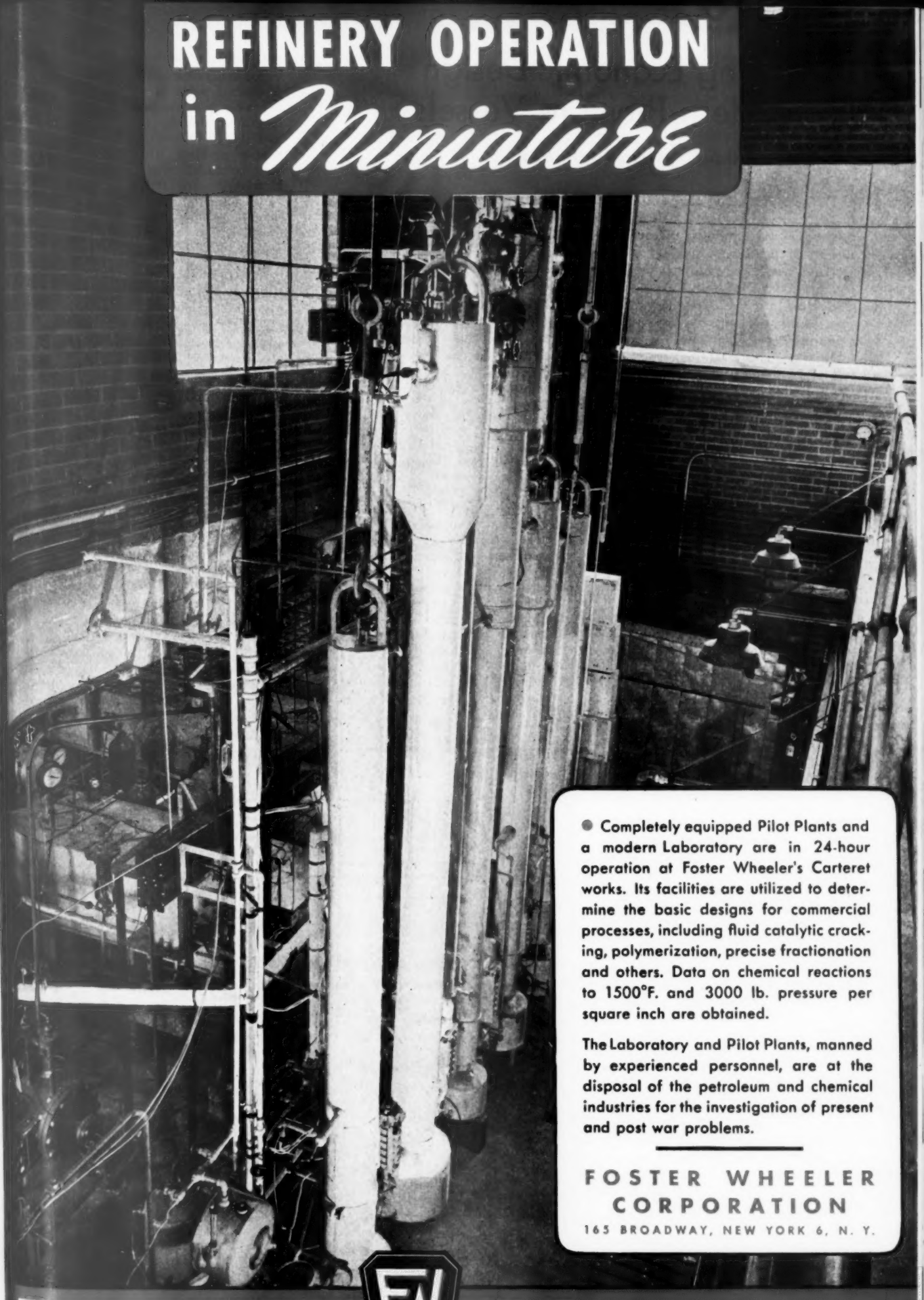
REFINERY OPERATION in *Miniature*



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Discussing Economic Design Of Modern Pressure Vessels

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The series is offered to provide refiners and design engineers fundamental data that will aid in the selection of tanks of economic design and is not intended to favor any particular design.

*By E. F. Brummerstedt**

IN REFINERY DESIGN the question of economical storage of liquids or gases at various pressures arises frequently. Because of the number of variable factors involved, this problem often defies simple mathematical analysis, and is usually solved by rule-of-thumb approximations or comparative cost analysis of several alternate schemes—essentially a trial-and-error method.

For non-pressure storage tanks of large size API Standard No. 12-C attempts to solve the problem by listing typical tank sizes based on 72 in. and 96 in. wide courses, from which the refiner can easily pick the most suitable dimensions for his required capacity, based on plant size and erection equipment. Tank fabricators also have issued many bulletins which adequately cover the subject. Hence this series of articles will be limited to pressure tanks designed in accordance with the API-ASME Code for Unfired Pressure Vessels.

Since cost is primarily proportional to the weight of steel required for the tank, mathematically the problem appears to evolve into one giving the minimum weight of steel per given volume of container. Since weight is a function of shell area and thickness, for a given shell thickness the problem reduces to that of a container of minimum area per unit volume. This, of course, is a sphere, or surface of revolution formed by revolving a circle about a diameter. In addition to having a minimum shell area, a sphere also has a minimum shell thickness, since the stress due to internal pressure in a spherical surface is only half that in a cylindrical surface of the same diameter. However, not all pressure storage tanks are spherical. Hence there must be certain other factors besides weight of steel that enter into the cost of a tank.

The most important of these is the labor required to transform the steel plates obtained from the mill into the proposed shape. The formation of spherical segments requires special equipment not possessed by the average welding shop or field construction crew; hence the construction of larger spheres is limited to a few companies having this special equipment. For smaller spheres the unit labor, that is amount of labor required per unit of weight, is often so much higher than for other shapes that the sphere is no longer economical below a given capacity, depending on shop or field equipment and labor resources. Other factors mitigating against the use of spherical shells are plant layout and transportation facilities for shop-welded equipment. Both of these factors usually favor long cylinders of equal capacity and smaller diameter. Spherical tanks are used to meet the requirements for handling special products or under conditions which offset these and other general factors in tank design.

Assuming that a shop-welded cylinder is desired, what is the optimum shape, i.e., what is the most economical ratio of length to diameter for a given capacity and design pressure? This would be a simple problem if the shell thickness were constant regardless of diameter. However, since the thickness of shell varies directly with the diameter, the determination of the optimum L/D ratio involves many variables and requires several simplifications.

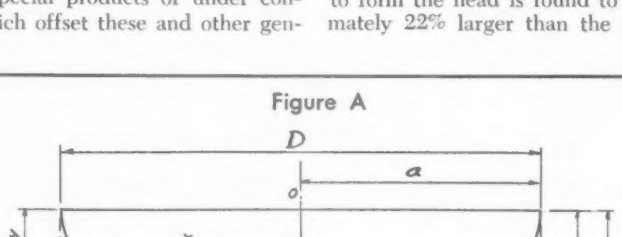
Ellipsoidal Head Analysis

The cylinder will be assumed to have 2:1 ellipsoidal heads. Except for low pressures (as will be shown in a subsequent analysis) they are the cheapest and best type. Even though made in one piece, the heads will have the same thickness as the shell, in accordance with standard practice and code regulations.

The volume of an ellipsoidal head is equal to that of a cylinder of identical diameter whose height is equal to 2/3 of the depth of dish of the head. Since a 2:1 ellipsoidal head has a depth of dish equal to ¼ of its diameter, (the minor axis being one-half the major axis), the height of an equivalent cylinder is 2/3 x 1/4 = 1/6 of the diameter. Their values can be easily checked by reference to handbooks and trade catalogues, or mathematically by integral calculus. (See Fig. A).

The surface area of a 2:1 ellipsoidal head can also be obtained from trade catalogues, or checked by calculus. The diameter of a flat circular plate required to form the head is found to be approximately 22% larger than the head diam-

Figure A



ANALYSIS OF 2:1 ELLIPSOIDAL HEAD

Equation of surface of revolution about axis O-O:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Since by definition, $a = 2b$,

$$\frac{x^2}{4b^2} + \frac{y^2}{b^2} = 1$$

Simplifying, $x^2 + 4y^2 = 4b^2$

or $x^2 = 4b^2 - 4y^2 = 4(b^2 - y^2)$

Now $dV = A\,dy = \pi x^2 dy$

and $V = \int_0^b \pi x^2 dy = 4\pi \int_0^b (b^2 - y^2) dy$

$$= 4\pi \int_0^b b^2 dy - 4\pi \int_0^b y^2 dy$$

and $V = 4\pi \left[b^2 y - \frac{y^3}{3}\right]_0^b = 4\pi\left(b^3 - \frac{b^3}{3}\right) = \frac{8}{3}\pi b^3 = \frac{\pi a^3}{3}$

Vol. of equivalent cylinder $= \pi a^2 c$

hence $c = \frac{a}{3} = \frac{D}{6}$

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eter. Hence the area =

$$\frac{\pi}{4}(1.22\,D)^2 = \frac{\pi}{4}(1.48\,D^2) = 1.16\,D^2.$$

The cost of forming these heads at the mill (refer to Lukens' Flanging and Pressing Catalog No. 1) is somewhat higher per unit area than the average shop cost of rolling and welding rectangular plates into cylinders. For reasons of mathematical simplification this increase in cost per unit head area will be assumed as 50% over that of unit cylindrical shell area, which is an average figure based on welding shop cost analysis.

Mathematical Analysis

Based on the above simplification, the following mathematical relationships can be set up:

1. Volume of Cylindrical Tank

$$V = \frac{\pi D^2}{4}\left[L + 2\left(\frac{D}{6}\right)\right]$$

$$\text{or } V = \frac{\pi D^2 L}{4} + \frac{\pi D^3}{12} \qquad (1)$$

$$\text{and } L = \frac{4V}{\pi D^2} - \frac{D}{3} \qquad (2)$$

where L = Length of cylinder
and D = Diameter of cylinder

2. Area of Cylindrical Tank A =

$$\pi D\,L + 2\,(1.16\,D^2)$$
$$= D\,(\pi L + 2.32\,D) \qquad (3)$$

3. Thickness of tank shell for any pressure

$$P = t = \frac{PD}{2S - P} \qquad (4)$$

(assuming no corrosion allowance)
where S = allowable steel stress which is a constant under 650° F.

(API-ASME Code Fig. 1).

4. Weight of steel tank for given pressure = area X thickness X density of steel

$$\text{or } W = t\,w\,D\,(\pi L + 2.32\,D)$$

where w = weight of steel per unit volume. (5)

For ultimate reduction to a single variable D, t and w can be evaluated as a function of D for a given pressure P.

$$\text{For } P = 250 \text{ psi, } t = \frac{250\,D}{2\,S - 250}$$

S is based on the ultimate tensile strength of the steel and the efficiency of the welded longitudinal joint. For the standard ASTM A-70 firebox steel the ultimate tensile strength is specified as 55,000 psi, the factor of safety 4 and the efficiency of a double-butt welded stress-relieved joint 85%. (API-ASME Code)

Hence

$$S = \frac{55{,}000 \times .85}{4} = 11{,}700 \text{ psi.}$$

and

$$t = \frac{250\,D}{2 \times 11{,}700 - 250} = .0108\,D.$$

neglecting corrosion allowance, wherein t will be in the same unit of measurement as D.

For simplicity and consistency, for a given volume in cu ft, L and D should be kept in feet, and A in sq ft.

Since steel plate, including 5% overweight tolerance, weighs 515 lb/cu ft = w, and t = .0108 D,

$$tw = .0108\,D \times 515 = 5.53\,D$$

Hence the weight of a cylindrical pressure tank designed in accordance with the above conditions in lbs. =

$$W = 5.53\,D^2\,(\pi L + 2.32\,D)$$
$$= 17.30\,D^2\,(L + .74\,D) \qquad (6)$$

To calculate the cost, the equivalent cost area must be calculated, which involves increasing the actual head area by the 50% increase in cost given above, or

Equivalent cost area

$$= \pi DL + 1.5\,(2.32\,D^2)$$
$$= D\,(\pi L + 3.48\,D)$$

The equivalent cost weight is then adjusted accordingly from equation (6), to

$$W' = 17.30\,D^2\,(L + 1.11\,D) \qquad (7)$$

The unit cost of this adjusted weight varies inversely with the thickness in accordance with the empirical formula

$$X = K - 1.75\,t \qquad (8)$$

This expression is based on a curve of many shop-fabricated vessels whose cost per pound was plotted against their thicknesses, and wherein

X = cost in cents per pound, adjusted for thickness.
K = basic cost constant per pound based on shop labor rates and standards. In this analysis K = 8, based on shop cost analysis.
t = thickness in inches up to 2 in. inclusive.

Since t = .0108 D if D is in inches,
and t = .1296 D if D remains in feet, the value of X can be expressed as 8 − .226 D.

The cost in dollars is then

$$\frac{X}{100}(W')$$

$$\text{or } C = \frac{8 - .226\,D}{100}[17.3\,D^2\,(L + 1.11\,D)]$$

Simplifying,

$$C = (.08 - .00226\,D)\,(L7.3\,D^2L + 19.2\,D^3)$$

$$\text{or } C = 1.385\,D^2L - .039\,D^3L + 1.536\,D^3 - .0432\,D^4 \qquad (9)$$

For computing the cost for given values of L and D, this can be further simplified to

$$C = 1.385\,D^2\,(L - .0282\,DL + 1.11\,D - .0312\,D^2) \qquad (10)$$

In order to calculate the minimum cost dimension directly, the variable L must be eliminated, leaving the entire expression in terms of D.

Substituting

$$L = \frac{4V}{\pi D^2} - \frac{D}{3} \text{ in equation (9),}$$

$$C = 1.385\,D^2\left(\frac{4V}{\pi D^2} - \frac{D}{3}\right) - .039\,D^3\left(\frac{4V}{\pi D^2} - \frac{D}{3}\right) + 1.536\,D^3 - .0432\,D^4$$

$$\text{or } C = 1.76V + 1.074\,D^3 - .0495\,DV - .0302\,D^4$$

The minimum value of C is then found directly by differentiating the above expression and solving for D when the derivative equals zero.

Thus

$$\frac{dC}{dD} = 3.222\,D^2 - .0495V - .1208\,D^3 = 0$$

$$\text{or } D^3 - 26.7\,D^2 + .410V = 0 \qquad (11)$$

For a tank of 25,000 gal. capacity, V = 3,340 cu ft, and the above expression becomes $D^3 - 26.7\,D^2 + 1370 = 0$
This can be solved for D = 8.75 ft as the most economical diameter. The corresponding value of

$$L = \frac{4 \times 3340}{3.14 \times (8.75)^2} - \frac{8.75}{3} = 52 \text{ ft.}$$

The economical ratio of length to diameter is therefore equal to

$$52/8.75 = 5.94 \text{ or } 6 \text{ (approx.)}$$

In practice the tank would be dimensioned 9 ft. x 49 ft. 6 in. to give an even diameter. Table 1 indicates the various diameters that may be assumed for this capacity and the cost calculated per equation (10) bears out the result obtained directly by differential calculus.

The table shows, however, that no matter what ratio of length to diameter is chosen, the cost does not vary sufficiently to ignore other considerations in the design, such as plant layout, symmetry, foundations, etc. These factors will often govern the design, and this analysis shows that such a procedure would not necessarily be uneconomical.

For tanks of lower pressure where flanged and dished heads can be used, the above ratio of L/D would decrease to 3 or 4:1, since the ratio of cost of unit head to shell area would decrease from 1.5 to about 1.3. Adding the usual ⅛ in. corrosion allowance increases the cost of all items proportionately, but does not appreciably affect the minimum cost ratio.

TABLE 1—Economic Tank Design

V = 25,000 gallons = 3,340 cu ft.
P = 250 psi. No corr. allowance.

Case Formula	Dia. ft Assumed	Length, ft (2)*	Ratio L/D	Area, sq ft (3)*	Thickness, in. (4)*	Wt. lbs. (6)*	Cost (10)*
1	12	25.5	2.1	1296	1 5/16	86,000	$5,110
2	11	31.5	2.9	1370	1 7/16	83,000	5,050
3	10	39.25	3.9	1462	1 5/16	81,000	5,010
4	9	49.5	5.5	1588	1 3/16	78,700	4,980
5	8.75	52	6	1605	1⅛	77,500	4,930
6	8.5	56.25	6.6	1670	1⅛	78,000	4,980
7	8	64.0	8	1758	1 1/16	77,300	5,010
8	7	84.5	12	1944	1/16	76,000	5,040

*See equation of the same number in the text.

Developments to Raise Ignition Qualities Of High-Speed Diesel Fuels Explained*

Developments in recent years in the use of Diesel engines make it important to find economical means, such as by the use of additives, to raise the ignition qualities of high-speed diesel fuels. The hundreds of materials which have been proposed as cetane number improvers are arranged in 11 groups and their properties described briefly. The effect upon cetane numbers when ethyl nitrate, isoamyl nitrate, commercial amyl nitrate and acetone peroxide are added to four types of straight-run and cracked stocks are shown. Data indicate that acetone peroxide is probably the most effective, reasonably stable ignition accelerator and commercial amyl nitrate the most effective semi-commercially available accelerator. Costs are given for improving cetane numbers with commercial amyl nitrate. Illustrations are given of the effect of accelerators in general on other properties of diesel fuels.

An extensive literature and patent search is appended to the paper, which is not published here; also charts presented with the paper are omitted.

By J. S. Bogen** and G. C. Wilson**

DEVELOPMENTS in the field of high-speed diesel engines have brought them into extensive use for automotive-type service. At the close of 1941, there were in the U. S. approximately 10,000 commercial vehicles equipped with this type of engine. During the past three years, the widespread use of such engines for trucks, tractors and marine purposes by the military and naval forces has increased the demand for high-speed diesel fuel. In general, these engines require a supply of volatile, high-cetane fuel; moreover, this supply should be produced in or near the district where the engines are operated or refueled. In the East, where straight-run paraffinic-type stock is available in quantities, the problem is not serious. On the West Coast, however, where the straight-run fuel has an ignition quality below that required by most engines, there is need for a simple solution to the problem of improving this property of the fuel.

In the past, one of the outstanding advantages of the Diesel engine has been its ability to operate economically on low-cost fuel. A survey of a number of engine manufacturers has indicated that a rise of 12% in Diesel fuel cost will offset any advantage of economy which this type of engine may have at the present time. This narrow margin leaves very little opportunity for the application of quality-improving refining processes. Moreover, if distribution costs are to be kept to a minimum, it is necessary to restrict marketing to a single grade of automotive Diesel fuel.

The refiner's problem becomes very simple when the source of his crude oil is such that a straight-run cut meets the specifications for high-speed Diesel fuel. In cases where the refiner is working with nonparaffinic crudes, his problem of meeting a 50-cetane number requirement will range all the way from gaining a few cetane numbers to the greater difficulty of raising the rating of his product 20 or more cetane numbers. It is necessary that an economical solution, such as the use of additives, be found for raising the ignition quality a few cetane numbers.

In some localities the refiner who markets Diesel fuel may, of necessity, have to produce high-speed Diesel fuel from low-cetane stock, such as thermal-recycle gas oil or unfavorable crude oils. In cases where the fuel must be improved by 18 to 20-cetane number, either the stock may be blended with high-cetane material or special processes may be used.

The effectiveness of solvent refining and hydrogenation for this purpose has been studied by Dryer, Chenicek, Egloff and Morrell (1). They have found that fuels of high ignition quality can be prepared by extraction alone or by solvent extraction and doping, but that a pour-point depressant may be required. Also, they state that the high blending values of the extracts suggest their use as blending stocks for tractor fuels.

Hydrogenation produces fuels of high ignition quality without loss of fuel or change in physical properties, such as pour point, flash point and distillation range; but solvent extraction offers greater possibilities since it can be adapted for use on a wide range of stocks irrespective of their sulfur content. In most cases these processes are prohibitive in cost. Under normal circumstances many refiners do not find it advantageous to produce Diesel fuel, since they can obtain approximately the same price for burner oil without the necessity of adhering to such strict specifications.

In addition, the refiner who supplies Diesel fuel usually is called upon to maintain an expensive technical service organization to care for the complaints which often arise from faulty engine usage.

In 1940, the C.F.R. Automotive Diesel Fuels Division Full-Scale Engine Group, working under C. G. A. Rosen's supervision, conducted a series of tests in which the same four fuels were used in seven different makes of engines. In W. G. Ainsley's report (2) on this series of tests, it was shown that with an increase in cetane number of the fuel, exhaust odors and smoke, engine roughness, engine deposits and starting difficulties all decreased. Some engines show a greater sensitivity to ignition quality of the fuel than do others of different design. More recent investigations along the same line serve to substantiate the results reported by Mr. Ainsley with one possible exception—that pertaining to smoke.

The data were not conclusive at that time and later investigation bears out the stated belief that some other factors overshadow any defect of cetane number in so far as smoke is concerned. In fact, it is known that operation with some high-cetane fuels under certain conditions results in more black smoke in the exhaust than does the use of lower cetane fuels.

The conclusion of the group was, that to insure satisfactory operation in all of the high-speed engines included in the series of tests, the fuel should have a minimum-cetane number of 47. On the basis of this conclusion, 50-cetane number fuel has been established as a satisfactory minimum requirement for all automotive-type Diesel engines in general service.

Combustion in Diesel Engines

The cetane number of a Diesel fuel is a good indication of its ignition qualities and of the duration of the delay period between the time of injection and ignition. In general, it is related to the magnitude of cylinder peak pressures and rough running in most high-speed Diesel engines. The few engines which are not cetane sensitive are those which have combustion chambers designed to avoid high peak pressures even though required to operate on relatively low-cetane fuel. Spontaneous ignition temperature (S.I.T.) of a fuel is also a factor in its ignition quality. While a low S.I.T. is a definite asset for im-

* Originally presented under the title "Ignition Acceleration for Compression-Ignition Engine Fuels" before the Society of Automotive Engineers meeting, Detroit, Jan. 14, 1942, this paper has been revised and brought up-to-date to include recent developments in this field. A literature and patent search ap-pended to the paper is omitted in this publication. The charts with the paper are also omitted, as the same data are given in the tables.

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proved ignition quality, there are several other important properties. Boerlage and Broeze have shown that the cracking tendency of a fuel is related to its ignition qualities (3).

The commonly accepted theory that the high peak pressures following a long delay period are due entirely to an accumulation of unburned fuel in the combustion chamber is incorrect. It has been shown by a large number of oscillograms taken with the Rose Indicator at the University of Wisconsin (4) that other factors are more important than the quantity of fuel injected before ignition occurs.

Two fuels, with ignition qualities of 19-cetane number and 70-cetane number, respectively, were injected into an open-combustion chamber engine running at 1250 rpm. The duration of injection was short, about 12 degrees of crank travel, so that in every case all the fuel was injected before any of it started to burn. The delay period was increased by advancing the time of fuel injection. All the fuel was injected during a period of 1.6 milliseconds, but rough running and knocking did not occur until the delay period exceeded 2 milliseconds.

The injection timing at which knocking began was 20° B.T.C. (ignition lag 2.04 milliseconds) for the low and 46° B.T.C. (ignition lag 3.14 milliseconds) for the high-cetane fuel, and the knock intensity increased as injection timing was advanced until violent knocking conditions occurred at a timing of 29° B.T.C. (ignition lag 4.1 milliseconds) for the low and 54° B.T.C. (ignition lag 4.59 milliseconds) for the high-cetane fuel.

This indicates clearly that, the longer a definite quantity of fuel is exposed to the temperature and pressure of the air in the cylinder during the compression stroke, the greater the combustion shock when it finally ignites. Thus, the duration of such exposure is as important as the accumulation of fuel during the delay period.

Therefore one may conclude that preflame reactions of the fuel play an important part in determining the rapidity of its combustion.

Means for Controlling Combustion

Inasmuch as it is possible to design Diesel engines for operation on low-cetane fuel, there has been much debate as to whether or not there is need for a high-cetane fuel. However, the demands of automotive-engine service are for a reduction in weight and space requirements of the power plant. In general, any attempt to show a saving in fuel because of increased cetane numbers has been disappointing. For engines operating within moderate speed ranges (below 1800 rpm), the thermal efficiency of any given engine stays surprisingly constant for a wide range of fuels. Thus, so far as fuel economy is concerned, the heating value of the fuel is the most important consideration. Simplification of design and reduction in weight per horsepower, together with the expectation of reduced maintenance problems, have led most high-speed Diesel engine builders to accept the need for fuel with a cetane number of 45 or better. In the past, refiners have been able to meet this demand by proper selection of their products.

TABLE I—Cetane Numbers for Straight-Run Diesel Fuels from U. S. Crude Sources, Arranged Geographically

(Data for this table taken from references 11 and 12 in bibliography.)

	Crude Source	Type of Crude* P	N	A	Cetane No.
1.	Pennsylvania	85	9	6	65
2.	Pennsylvania	85	9	6	62
3.	Kentucky	73	12	15	52
4.	Michigan	83	9	8	68
5.	Michigan	66	15	19	56
6.	Indiana	74	12	14	52
7.	Illinois	74	12	14	52
8.	Midcontinent	75	12	13	55
9.	Kansas	69	14	17	59
10.	Oklahoma	75	12	13	56
11.	Louisiana	89	7	4	63
12.	Gulf Coast	75	12	13	58
13.	South Texas	47	21	32	33
14.	South Texas	45	22	33	32
15.	East Texas	75	12	13	55
16.	East Texas	70	14	16	57
17.	West Texas	83	9	8	64
18.	West Texas	69	14	17	48
19.	West Texas	67	15	18	45
20.	New Mexico	58	17	25	48
21.	Rocky Mountain	73	12	15	51
22.	Wyoming	80	10	10	68
23.	Wyoming	73	12	15	59
24.	California	69	14	17	47
25.	California	64	16	20	45
26.	California	56	18	26	41

*The type of crude is defined by stating the approximate amounts of the different types of hydrocarbons in the straight-run diesel fuel, as indicated by laboratory data and UOP Characterization Factor. (5)

P = Paraffins, in %
N = Naphthenes, in %
A = Aromatics, in %

It has been pointed out that both the nature of the crude oil and the process of refining affect the ignition qualities of a Diesel fuel. Table I shows cetane number ratings for straight-run Diesel fuels produced from almost every major oil field in the U. S. While these figures undoubtedly are accurate for the particular samples tested, samples will differ somewhat within any given locality. It is interesting to note that about 30% of these straight-run fuels are less than 50-cetane number. It has been pointed out by several investigators that high ignition quality, in many cases, is linked up with the presence in the fuel of paraffinic chains (3). This fact is emphasized by the data in Table I. The type of crude oil has been defined in terms of the division of the straight-run product among paraffins, naphthenes and aromatics, in percentages. While these values are approximations from calculations depending upon UOP Characterization Factor (5), they may be regarded as sufficiently accurate for purposes of comparison.

Other means for supplying a fuel of satisfactory combustion characteristics are the use of special processes or the use of additives. The use of special processes has been discussed previously. The remainder of this paper is devoted to a detailed study of diesel fuel ignition accelerators.

Ignition Accelerators

The hundreds of materials that have been proposed as ignition accelerators have been arranged in 11 groups. An extensive literature and patent search has been made and the information classified. A complete bibliography is furnished at the close of this paper. As an introduction to the detailed study of a few of the possible additives, each of the major groups are discussed in the following paragraphs.

A. Aliphatic hydrocarbons.—Examples of this class of ignition accelerators are acetylene, allylene, divinylacetylene and butadiene.

These compounds are relatively ineffective as ignition promoters when compared with the nitrates and peroxides, and consequently must be added in reasonably large concentrations. The mechanism of the reaction appears to be oxidation of the olefinic double bond, which produces sufficient thermal energy to cause ignition. (16 references).

B. Aldehydes, ketones, ether, esters, etc.—These compounds may be exemplified by furfuraldehyde, acetone, diethyl ether, ethyl acetate, nitroglycerine and methyl alcohol.

They have an order of effectiveness slightly greater than that of the aliphatic hydrocarbons; however, diethyl ether is excellent for starting, whereas the other compounds are not. The most logical explanation of the mechanism of the operation seems to be that under engine operating conditions this type of compound is thermally unstable and therefore may be readily ignited. Nitroglycerine, being an explosive, is very unstable under temperature and pressure. (61 references)

C. Metal derivatives.—Some examples of this group are barium nitrate, copper oleate, manganese dioxide, potassium chlorate and vanadium pentoxide.

In general, the effectiveness of these compounds is just slightly less than that of the aliphatic hydrocarbons and the peroxides. Some are the ingredients of explosives, e.g., potassium chlorate. The pentoxides, e.g., vanadium pentoxide, apparently have a dual effect, that of the metal and that of the oxygen, and they are unstable under engine operating conditions. The exact action of the metals is not understood and, like the

action of tetraethyl lead in the Otto cycle, is subject to many explanations. (29 references)

D. Alkyl nitrates and nitrites and nitro compounds—Typical of this group are ethyl nitrate and ethyl nitrite.

This class of compounds is highly effective in promoting ignition in the Diesel engine, being exceeded only by certain of the peroxides. Ignition is apparently caused by the action of the nitrate or nitrite group. These compounds are semi-explosives. (92 references)

E. Aromatic nitro compounds.—These may be exemplified by nitrobenzene or nitronaphthalene. Their action is essentially the same, but they are less effective than the alkyl nitrates because of the stability of the aromatic ring. (42 references)

F. Nitration.—Nitration of the fuel produces many compounds to which the nitrate group is attached. In general, they are less effective than the alkyl nitrates because of the lower ratios of the weights of the nitrate group to those of the hydrocarbon portion of the compound. However, the action is similar. (9 references)

G. Oximes and nitroso compounds.—Examples of this group are formaldoxime and nitrosomethylmethane. In general, these compounds have an effectiveness approximately halfway between that of the aliphatic hydrocarbons and alkyl nitrates. Again, the effectiveness is due to thermal instability and the action of the nitroso group. In other words, they are good oxidizing agents. (4 references)

H. Oxidation and oxidation products.—Oxygen and ozone are two typical examples of the class of materials included in this section. Their effectiveness is relatively low and their action is explained by the fact that the rate of oxidation is increased by the greater concentration of oxygen. (28 references)

I. Peroxides.—Acetone peroxide is the most prominent example of the peroxide class. It is slightly more effective than the alkyl nitrates, and therefore heads the list so far as effectiveness is concerned. These compounds are of an explosive nature and are effective because of their extreme instability. (49 references)

J. Polysulfides.—A representative of the polysulfide group is diethyl tetrasulfide. In general, the polysulfides have an effectiveness on the order of the oximes. Perhaps this is to be expected, since the sulfur portion of the compound reacts in a manner similar to oxygen compounds. (22 references)

K. Unclassified.—This section includes various materials upon which information was insufficient to justify a separate section. Some of these are the halogens, sulfur and certain sulfur compounds, and the amines. The sulfur and sulfur compounds have an action similar to that of the polysulfides and all compounds with the exception of the thionitrates and thionitrites have an order of effectiveness similar to that of the polysulfides. The thionitrates and thionitrites, along with certain of the chloronitro compounds, e.g., trichloronitromethane, are so very effective that they rank with acetone peroxide.

In addition, these compounds have a marked effect upon the starting characteristics of the fuel which is contrary to that observed for most of the other materials. Although not considered practical at this time, chlorine is exceedingly effective for both starting and normal operation. The action of the amines as ignition accelerators is exceedingly questionable. Certain of them in combination with nitroso groups are effective but amines as such, e.g., aniline, are definite antiknock agents for the Otto cycle engine. (87 references)

A rough generalization in regard to the solubility of the various ignition accelerators may be made i.e., the more effective the ignition accelerator, the less soluble in Diesel fuel.

It is surprising to find a number of compounds mentioned in the literature and patent search which, according to accepted theories, could have but little of the desired effect and would be expected to have the opposite effect. Among these are aniline, benzene, iron pentacarbonyl and ammonia, all of which are known to have antiknock properties when used in the spark ignition engine. Consequently, a certain amount of caution must be exercised in the use of this literature search. Since an attempt was made to have the search as nearly complete as possible, nothing was omitted even though some of the material is of doubtful value; 303 references are included in the 11 sections. They are cross-indexed both as to compound type and general classification. It is interesting to note that the sections may be listed in the following order of their prominence, as shown by the number of individual references in each section.

D. Alkyl nitrates and nitrites—93
B. Aldehydes, ketones, ethers, esters, etc.—60
I. Peroxides—49
E. Aromatic nitro compounds—42
C. Metal derivatives—29
H. Oxidation and oxidation products—28
J. Polysulfides—22
A. Aliphatic hydrocarbons—16
F. Nitration—9
G. Oximes and nitroso compounds—4

The fact that the alkyl nitrate and nitrite section shows the most references probably explains why these compounds have most nearly approached commercial development.

It should also be noted that the statements as to the effectiveness of the various classes are based on values obtained by this laboratory and it is realized that they do not agree completely with some of the previously published results.

Tables II and III show the comparative effectiveness of some of these additives when applied to a given fuel. Table II is for a 50-cetane fuel and Table III is for a 44-cetane fuel.

TABLE II—Effect of Various Ignition Accelerators

Cetane Number of a Midcontinent, Straight-Run Diesel Fuel to Which Has Been Added 2% by Weight of the Following Compounds

Compound	Cetane No.
Midcontinent straight-run (undoped)	50
Tetrabromethane	50
Normal butyl bromide	50
p-Aminodimethylaniline	43
Amylamine	50
Copper oleate	50
Nitrobenzene	50
Trinitrotoluene	52
Benzoyl peroxide	59
Acetone peroxide (Table V)	76
Nitromethane (insoluble)	..
Ethyl nitrate (Table V)	67
Isoamyl nitrate (Table V)	69

TABLE III—Cetane Improvement for Various Alkyl Nitrates

When 1.5% is added to a base fuel of 44 cetane number.

Alkyl Nitrate	Cetane No. Base Fuel Plus 1.5% Alkyl Nitrate	Increase in Cetane Number
Mixed amyl nitrates	63	19
Normal amyl nitrate	67	23
Normal butyl nitrate	63	19
Isopropyl nitrate	61	17
Octyl nitrate	63	19
Cyclohexyl nitrate	66	22
Secondary hexyl nitrate	62	18
Secondary amyl nitrate	64	20
Isoamyl nitrate	65	21
Normal hexyl nitrate	64	20

Note: The data for this table were furnished in private communication from Sharples Chemicals, Inc., Philadelphia. (January, 1941).

Study of Prominent Accelerators

The effects upon cetane number of 3 different ignition accelerators, i.e., ethyl nitrate, isoamyl nitrate, and acetone peroxide when they are added to 4 types of straight-run and cracked stocks, are shown in Tables IV through IX. Inspection of the data indicates that these 3 types of ignition accelerators raise the cetane number of the stocks to which they are added in the order of ascending effectiveness listed below:

Ethyl nitrate
Commercial amyl nitrate
Isoamyl nitrate
Acetone peroxide

In general, fuels of high-cetane number are more responsive to additions of ignition accelerators than those of low-cetane number. This agrees with the findings of Broeze and Hinze (6). This is the opposite effect from that usually noted when tetraethyl lead is added to gasoline, since the lead susceptibility of most gasolines decreases as the octane number rises. The data in the previous

curves are summarized in Table VIII.

If exact values are needed on the susceptibility of a fuel to the addition of any type of additive it is necessary that engine determinations be made. The susceptibility of fuels to additives is different in various engines. For example, when ethyl nitrate is added to a fuel and is run in both a C.F.R. Diesel engine, by the Delay Method, and in the submarine-type Fairbanks-Morse engine, 5% of ethyl nitrate increases the ignition quality an average of 38-cetane numbers in the submarine engine and only 19 in the C.F.R. engine.

The effect of ignition accelerators on physical properties of Diesel fuels is clearly shown in Tables V and VI. The most pronounced effect of the additives is on the flash point and Conradson carbon figures. The reduction in flash point, for all but isoamyl nitrate, is of such magnitude as to cause the usual light Diesel fuel to fall below the 150 F. legal flash point. We know of no method of circumventing this serious obstacle except to have the initial boiling and flash points of the fuel high enough to stand the reduction caused by the additive. If the 90% and end point specifications

TABLE IV—Laboratory Inspection Data, Engine Ratings, and Calculated Ignition Qualities of Cracked and Straight-Run Diesel Fuels from Six Crude Sources

Fuels	Vis. @ 100°F. S.U.° Seconds	Grav. at 60°F. °A.P.I.	Conradson Carbon % by Wt.	Flash Point °F.	Pour Point °F.	I.B.P. °F.	E.P. °F.	Cetane Number Delay	Aniline Point °F.	Diesel Index No. (11)	Ignition Quality No. (13)	Viscosity Gravity No. (11)	Boiling Point Grav. No. (11)
1. Pennsylvania:													
a. Straight-run	38.2	40.8	0.020	170	15	372	662	61	178.9	73.0	39.3	0.812	173.1
b. Cracked	37.6	30.1	0.021	180	5	323	646	42	131.7	39.6	21.4	0.868	188.9
2. Midcontinent:													
a. Straight-run	35.4	37.5	0.004	145	—20	340	631	50	148.7	55.8	27.9	0.837	181.6
b. Cracked	35.6	28.2	0.140	182	—35	400	620	33	98.2	27.7	13.3	0.885	196.7
3. East Texas:													
a. Straight-run	40.0	36.2	0.010	240	20	488	660	58	170.8	61.8	34.3	0.839	179.5
4. West Texas:													
a. Straight-run	37.8	34.2	0.090	205	—25	410	638	47	150.4	51.4	27.2	0.846	184.1
5. East and West Texas:													
a. Cracked	36.3	30.3	0.097	265	10	370	650	38	118.8	36.0	18.4	0.862	191.1
6. California:													
a. Straight-run	38.8	33.5	0.050	170	0	378	676	41	142.0	37.6	19.2	0.847	186.5
b. Cracked	35.3	30.7	0.070	185	—35	416	628	33	101.5	31.2	14.7	0.872	194.1

°These values were obtained by conversion from kinematic viscosities (centistokes @ 100°F.)

TABLE V—Laboratory Inspection, Engine Ratings, and Calculated Ignition Qualities of Doped Mid-Continent Straight-Run Diesel Fuel—Comparative Data for Acetone Peroxide, Ethyl Nitrate and Isoamyl Nitrate

Mid-Continent Straight-Run with Various Diesel Dopes	Vis. @ 100°F. S.U.° Seconds	Grav. at 60°F. °A.P.I.	Conradson Carbon % by Wt.	Flash Point °F.	Pour Point °F.	I.B.P. °F.	E.P. °F.	Cetane Number Delay	Aniline Point °F.	Diesel Index No. (11)	Ignition Quality No. (13)	Viscosity Gravity No. (11)	Boiling Point Grav. No. (11)
1. Without Diesel Dope	35.4	37.5	0.004	145	—20	340	631	50	148.7	55.8	27.9	0.837	181.6
2. Acetone peroxide:													
0.5% by wt.	35.4	37.1	....	....	—10	....	....	61	148.1	54.8	....	0.839	....
1.0% by wt.	35.4	37.0	....	....	—15	....	....	65	147.2	54.5	....	0.839	....
2.0% by wt.	35.4	36.6	....	....	—20	....	....	76	146.1	53.5	....	0.841	....
3.0% by wt.	35.4	36.2	....	....	—20	....	....	81	145.4	52.6	....	0.843	....
4.0% by wt.	35.4	36.0	....	....	—20	....	....	85	144.7	52.1	....	0.844	....
3. Ethyl nitrate:													
0.5% by wt.	35.3	37.3	0.040	130	—15	210	626	57	147.8	55.1	27.1	0.838	182.6
1.0% by wt.	35.2	37.1	0.080	120	—15	216	630	63	147.1	54.6	26.7	0.839	183.1
2.0% by wt.	35.0	36.7	0.090	100	—10	198	628	67	145.7	53.5	26.3	0.842	183.4
3.0% by wt.	34.8	36.5	0.110	95	—15	198	625	75	144.4	52.7	25.9	0.844	183.7
4.0% by wt.	34.7	36.1	0.130	95	—20	202	622	80	143.1	51.5	25.1	0.847	184.8
4. Isoamyl nitrate:													
0.5% by wt.	35.3	37.2	0.070	140	—10	315	618	57	147.6	54.9	27.1	0.838	182.6
1.0% by wt.	35.3	37.2	0.100	140	—25	263	620	63	146.9	54.8	26.8	0.838	182.8
2.0% by wt.	35.1	36.9	0.180	130	—15	215	615	69	145.3	53.6	26.1	0.841	183.6
3.0% by wt.	35.0	36.7	0.210	130	—15	235	618	74	143.5	52.7	25.6	0.842	183.9
4.0% by wt.	34.9	36.4	0.250	130	—15	234	615	80	141.9	51.7	25.2	0.844	184.3

°These values were obtained by conversion from kinematic viscosities (centistokes @ 100°F.)

TABLE VI—Laboratory Inspection Data, Engine Ratings, and Calculated Ignition Qualities of Doped Mid-Continent Cracked Diesel Fuel—Comparative Data for Acetone Peroxide, Ethyl Nitrate and Isoamyl Nitrate

Mid-Continent Cracked with Various Diesel Dopes	Vis. @ 100°F. S.U.° Seconds	Grav. at 60°F. °A.P.I.	Conradson Carbon % by Wt.	Flash Point °F.	Pour Point °F.	I.B.P. °F.	E.P. °F.	Cetane Number Delay	Aniline Point °F.	Diesel Index No. (11)	Ignition Quality No. (13)	Viscosity Gravity No. (11)	Boiling Point Grav. No. (11)
1. Without Diesel Dope	35.6	28.1	0.14	182	—35	400	620	33	98.2	27.7	13.3	0.885	196.7
2. Acetone peroxide:													
0.5% by wt.	35.6	27.9	....	....	—35	....	....	41	96.8	27.0	....	0.886	....
1.0% by wt.	35.6	27.9	....	....	—35	....	....	44	96.1	26.8	....	0.887	....
2.0% by wt.	35.6	27.7	....	....	—35	....	....	52	94.8	26.3	....	0.888	....
3.0% by wt.	35.7	27.3	....	....	—35	....	....	59	93.9	25.6	....	0.890	....
4.0% by wt.	35.7	27.0	....	....	—35	....	....	65	93.2	25.2	....	0.891	....
3. Ethyl nitrate:													
0.5% by wt.	35.5	28.0	0.24	165	—35	256	604	37	95.2	26.7	12.9	0.886	196.8
1.0% by wt.	35.4	27.8	0.33	155	—35	192	602	40	94.6	26.3	12.7	0.887	197.2
2.0% by wt.	35.2	27.6	0.40	140	—35	193	600	47	93.7	25.9	12.5	0.890	197.3
3.0% by wt.	34.9	27.3	0.45	130	—35	206	588	52	93.2	25.4	12.2	0.892	198.1
4.0% by wt.	34.8	27.0	0.50	115	—35	190	604	56	92.7	25.0	12.1	0.894	198.4
4. Isoamyl nitrate:													
0.5% by wt.	35.5	28.1	0.24	180	—35	286	612	38	95.2	26.8	13.0	0.885	196.5
1.0% by wt.	35.5	28.0	0.33	170	—35	272	591	42	94.5	26.5	12.8	0.886	196.8
2.0% by wt.	35.4	27.7	0.41	170	—35	274	592	49	93.2	25.8	12.5	0.888	197.3
3.0% by wt.	35.3	27.6	0.48	165	—35	238	610	54	91.8	25.3	12.2	0.889	197.5
4.0% by wt.	35.2	27.2	0.55	160	—35	247	604	60	90.7	24.7	11.0	0.892	197.9

°These values were obtained by conversion from kinematic viscosities (centistokes @ 100°F.)

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are to be met, the Diesel fuel will have to be a rather narrow cut of the total possible fraction of crude which might ordinarily be used.

The inspection data indicate that the Conradson carbon increase, whether taken on the complete fuel or on the 10% distillation bottoms, is of sufficient magnitude to cause serious engine deposits. However all engine experience known to the authors indicates that deposits using doped fuels are no more serious than those obtained with clear fuels whose Conradson carbon on the 10% bottoms is equal to those of the doped fuel before the addition of the ignition accelerator. It is also interesting to observe that the increase in Conradson carbon with the addition of dope is more marked in cracked fuels; this is to be expected when the chemistry of ignition accelerators is considered.

All data known up to the present time indicate that acetone peroxide probably is the most effective, reasonably stable ignition accelerator, and commercial amyl nitrate is the most effective semicommercially available ignition accelerator.

Amyl nitrate is the only accelerator whose cost is reasonable and for which commercial production has been set up tentatively. Sharples Chemicals, Inc., has quoted a price of $1 per gallon for commercial amyl nitrate. This material is slightly less effective than the pure isoamyl nitrate, for which a large amount of data is given in the previously discussed tables. Its effectiveness is also very little different from that of ethyl nitrate. A number of investigators, ourselves included, have found that commercial amyl nitrate is stable in storage either when blended with a fuel or in the concentrated form. Fuel blends stored for over 3 years have shown no drop in cetane number or change in other properties due to the addition of the commercial amyl nitrate. The effect of various isomeric alkyl nitrates is shown in Table III.

Table X indicates the cost of increasing the ignition quality of various fuels, both straight-run and recycle stock, with commercial amyl nitrate. It is interesting to note that the peak cost for a California cracked stock amounts to approximately $0.0012 per cetane number per gallon, or approximately $0.02 per gallon to raise the average cracked stock to 50-cetane number. It would cost $0.006 per gallon to raise the average California straight-run fuel to 50-cetane number.

All data accumulated thus far show that ignition accelerators have a very minor effect on economy or power output of the Diesel engine; that is to say, if we compare a fuel of 50-cetane number clear to a fuel which has been brought to 50-cetane number by the introduction of a minor amount of ignition accelerator, the economy obtained and the power of the engine will be approximately the same. The dimin-

TABLE VII—Comparative Data for 3 Dopes When Added to Straight-Run and Cracked Diesel Fuels from 6 Crude Sources. Acetone Peroxide, Ethyl Nitrate, Isoamyl Nitrate

Fuel	Dope	Undoped	Cetane Numbers 0.5%	1.0%	2.0%	3.0%	4.0%
1. Pennsylvania:							
a. Straight run	Acetone Peroxide	61	74	77	85	91	98
	Ethyl Nitrate	61	72	76	81	91	99
	Isoamyl Nitrate	61	72	76	83	90	96
b. Cracked	Acetone Peroxide	42	52	56	64	70	75
	Ethyl Nitrate	42	49	55	63	66	71
	Isoamyl Nitrate	42	50	56	64	66	71
2. Mid Continent:							
a. Straight-run	Acetone Peroxide	50	61	65	76	81	85
	Ethyl Nitrate	50	57	63	68	75	80
	Isoamyl Nitrate	50	57	63	69	74	80
b. Cracked	Acetone Peroxide	33	41	44	52	59	65
	Ethyl Nitrate	33	37	40	47	52	57
	Isoamyl Nitrate	33	38	42	49	54	58
3. East Texas:							
a. Straight-run	Acetone Peroxide	58	67	74	80	84	89
	Ethyl Nitrate	58	67	71	79	82	85
	Isoamyl Nitrate	58	67	71	78	82	86
4. West Texas:							
a. Straight-run	Acetone Peroxide	47	55	59	70	75	80
	Ethyl Nitrate	47	52	58	64	70	75
	Isoamyl Nitrate	47	52	58	64	73	77
5. East and West Texas:							
a. Cracked	Acetone Peroxide	38	47	52	58	65	72
	Ethyl Nitrate	38	43	50	56	61	66
	Isoamyl Nitrate	38	44	50	57	62	67
6. California:							
a. Straight-run	Acetone Peroxide	41	51	55	60	68	74
	Ethyl Nitrate	41	47	51	59	63	67
	Isoamyl Nitrate	41	47	52	59	63	67
b. Cracked	Acetone Peroxide	33	41	45	51	57	63
	Ethyl Nitrate	33	39	44	49	53	57
	Isoamyl Nitrate	33	39	44	49	54	58

TABLE VIII—Average Cetane Number Improvement with Addition of 3 Diesel Dopes to the Fuels Listed in Table IV

(Averages from data of Table VII)

Diesel Dope	Average Increase in Cetane Number for Dope Additions 0.5%	1.0%	2.0%	3.0%	4.0%
Acetone peroxide	9.6	13.8	21.4	27.7	33.1
Ethyl nitrate	6.7	11.7	18.1	23.3	27.7
Isoamyl nitrate	7.0	12.1	18.8	24.0	28.6

TABLE IX—Amount of Dope Required To Raise the Fuels Listed in Table IV to 50-Cetane Number

(Per cent of dope by weight)

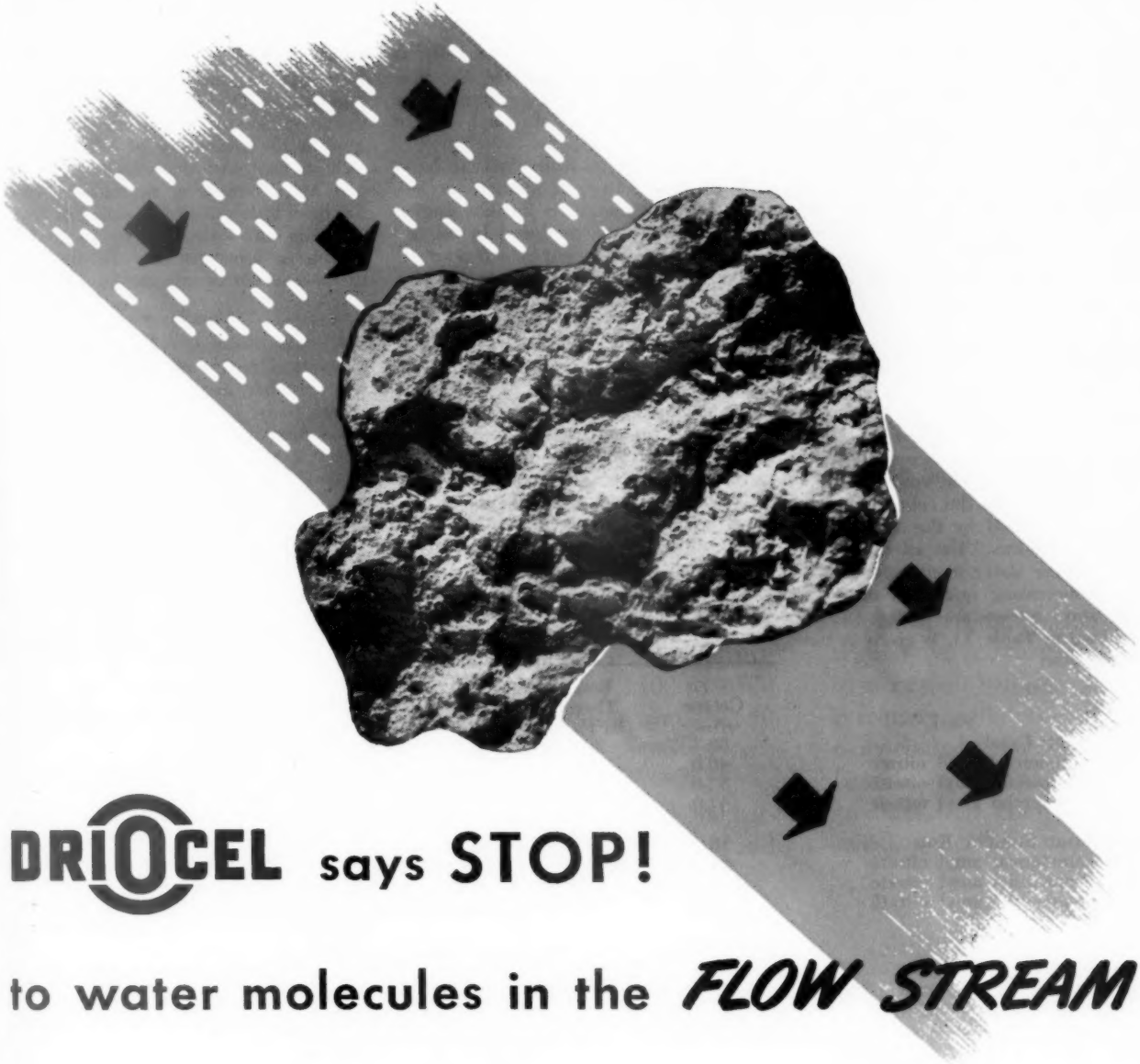
Crude Source	Cracked Mid-Cont.	Cal.	E. & W. Tex.	Penna.	Straight-Run Cal.	W. Tex.
Cetane Number	33	33	38	42	41	47
Acetone peroxide, %	1.70	1.80	0.80	0.40	0.50	0.15
Ethyl nitrate, %	2.40	2.33	1.10	0.55	0.80	0.30
Isoamyl nitrate, %	2.20	2.25	1.00	0.50	0.75	0.20

TABLE X—Cost of Increasing Ignition Quality to 50-Cetane Number with Commercial Amyl Nitrate for Cracked and Straight-Run Distillates from 5 Crude Oils

Fuel	Penna. Crkd.	Mid. Cont. Crkd.	California Str.-R.	California Crkd.	W. Tex. Str.-R.	E. & W. Tex. Crkd.
Cetane number	42	33	41	33	47	38
Dope required to equal 50-cetane number, % by wt.	0.50	2.20	0.75	2.25	0.20	1.00
Increase in cost by adding dope, cents per gallon of fuel	0.444	1.95	0.636	1.96	0.168	0.877
Cost per cetane number, cents per cetane number per gallon of fuel	0.0555	0.1147	0.0707	0.1153	0.056	0.073

NOTES: No dope is required for the following straight-run fuels: Pennsylvania—Cetane No. 61, Mid-Continent—Cetane No. 50, East Texas—Cetane No. 58.

Cost of commercial amyl nitrate taken as $1 per gallon, as estimated for quantity production.



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ished economy and power output of the fuel to which the ignition accelerator has been added is proportionate to the reduction in the heat content of the fuel. The reduction in the heat content of the fuel due to commercial amyl nitrate ignition accelerator is illustrated in Table XI, which also shows the low heat content of the commercial amyl nitrate, namely, 11,270 Btu/lb.

Data (7) obtained from the Fairbanks-Morse six cylinder, Model 36A, 4¼ in. bore by 6 in. stroke Diesel engine indicate that as the cetane number of the fuel is increased, whether by the addition of dope or by using a fuel whose inherent cetane number is high, the engine roughness and the rate of pressure rise are both reduced. Other observers (8, 9, 10) have found that engine roughness is reduced when the cetane number of the fuel is raised by the addition of ignition accelerators. The effect on the economy of the above mentioned engine (7) when increasing quantities of commercial amyl nitrate are added to the fuels shown in Table XI, is given in the following data:

Fuel	Cetane No.	Brake Therm. EFF.,%	Fuel Rate, LB/BHP/HR.
Mid-Continent Cracked	36.3	29.4	0.455
1% commercial amyl nitrate	46.0	29.2	0.460
2% commercial amyl nitrate	52.0	29.0	0.464
3% commercial amyl nitrate	57.0	29.2	0.464
Mid-Continent Straight Run	55.0	29.4	0.438
1% commerical amyl nitrate	68.9	29.4	0.441
2% commercial amyl nitrate	75.5	29.1	0.445
3% commercial amyl nitrate	80.5	28.9	0.452

This diminution in economy parallels the reduction in heat content, as indicated by the almost constant value of thermal efficiency. Incidentally, the thermal efficiency for this engine remained nearly constant at 29% for a series of tests covering a wide range of undoped fuels.

Data from the same source (7) reveal that commercial amyl nitrate has a negligible effect upon the duration of combustion. Other data (8, 9) show that ethyl nitrate tends to increase the primary burning rate but has little effect upon the secondary burning rate; also that the effect on the primary burning rate decreases rapidly with increasing percentages of ignition accelerator. Neither the completeness of combustion nor its effectiveness is changed by the addition of dope to the fuel.

Data for 30 different distillates are shown in Table XII. These data show a considerable variation in cetane response for some fuels, and serve to emphasize the need for caution in estimating the amount of commercial amyl nitrate required for any specific fuel problem. The part of this table which shows the increase in cetane number for each ½% increase in amyl nitrate shows that, in general, the first ½ of 1% supplies the greatest effect and that the increment of gain diminishes rapidly as more is added. Consequently, the proportionate gain in cetane number is small for quantities of amyl nitrate greater than 3%.

To date, all full-scale data at hand indicate that the use of ignition accelerators does not materially increase engine deposits over those produced by an undoped fuel of equivalent cetane number. There may be a slight increase in deposits using amyl nitrate. Even so, the difference of 6.1 g. deposit in 66 hours' running may be due to experimental error in scraping and collecting the deposit.

In general, ignition accelerators have little effect upon the low temperature starting ability of a fuel. For example, a fuel of 40-cetane number doped to 50-cetane number may still have the starting characteristics of a fuel of approximately 40-cetane number. This statement is substantiated by the fact that the critical-compression-ratio (C.C.R.) ratings for doped fuels are usually lower than the Delay ratings. This is a distinct disadvantage for a fuel whose cetane number is made up by the addition of an ignition accelerator. There are certain exceptions to this generalization, namely, the thionitrites, chlorine and such compounds as exemplified by trichloronitromethane. These compounds all have marked effects toward improving the starting characteristics of the fuel in which they are blended.

For maximum starting effect chlorine may be added to the intake air. This is also true for diethyl ether. However, the starting characteristics of the fuel itself may be improved materially by the addition of the ethers, e.g., diethyl ether, although these compounds apparently do not act as ignition accelerators since their effect is apparently due to the extreme volatility and high C.C.R. rating of the material. This is shown by the fact that as the number of carbon atoms in the alkyl chain is increased and the volatility drops, the effect of the additive as a starting agent is diminished.

If extensive use of the nitrates or peroxides as ignition accelerators for Diesel fuels is to be made, a study of their corrosive properties under engine operating conditions should be undertaken. Data procured in the authors' laboratory show that the peroxides are most corrosive and that the nitrates have a small effect. These compounds cause pitting of the injector nozzle tips, valves and seats. Data obtained from the 6-cylinder, 4-cycle, Fairbanks-Morse engine at the University of Wisconsin (7) indicate that corrosive effect of commercial amyl nitrate is negligible. There has been little extended running of doped fuels on full-scale engines so that no definite conclusions may be drawn as to their corrosive effects.

Conclusions

1. The use of ignition accelerators is a practical means of improving the cetane number and ignition qualities of Diesel fuels.

2. Amyl nitrate is the ignition accelerator most likely to be used because, to the authors' knowledge, it is the only one which has had commercial development at this time.

3. The cost of increasing the cetane number with ignition accelerators is dependent upon the susceptibility of the individual stock and the increase necessary, as well as on the ignition accelerator chosen. The average cost probably will be approximately $0.0010 per cetane number per gallon.

4. Ignition accelerators tend to reduce the flash point of usual Diesel fuels below the legal limits.

5. Ignition accelerators tend to increase the Conradson carbon on the 10% distillation bottoms but do not materially increase the carbon deposit formation in the engine.

6. Because of reduced net heat content, fuels to which large quantities of ignition accelerators have been added tend to show a poorer economy than those which by virtue of their natural properties have an equivalent cetane number.

7. Engine roughness is materially reduced by increasing the cetane number with ignition accelerators; however, the completeness of combustion is not affected.

8. With a few exceptions the majority of the ignition accelerators known to the authors have little effect upon the low-temperature starting quality of a Diesel fuel regardless of the quantity added.

9. Some ignition accelerators may have serious corrosive effects. Before any extensive use is made of these materials, a complete study of the corrosion tendencies should be made because there are too little data to allow prognostication at this time.

10. To date it is doubtful whether or not ignition accelerators can be economically justified. West Coast fuels need to have their cetane number increased by some method and it would seem most practical to use a combination of solvent extraction and small quantities of ignition accelerators. The solvent refining process will increase markedly the ignition accelerator susceptibility of the fuel.

11. It will be approximately one year from the time a commercial demand

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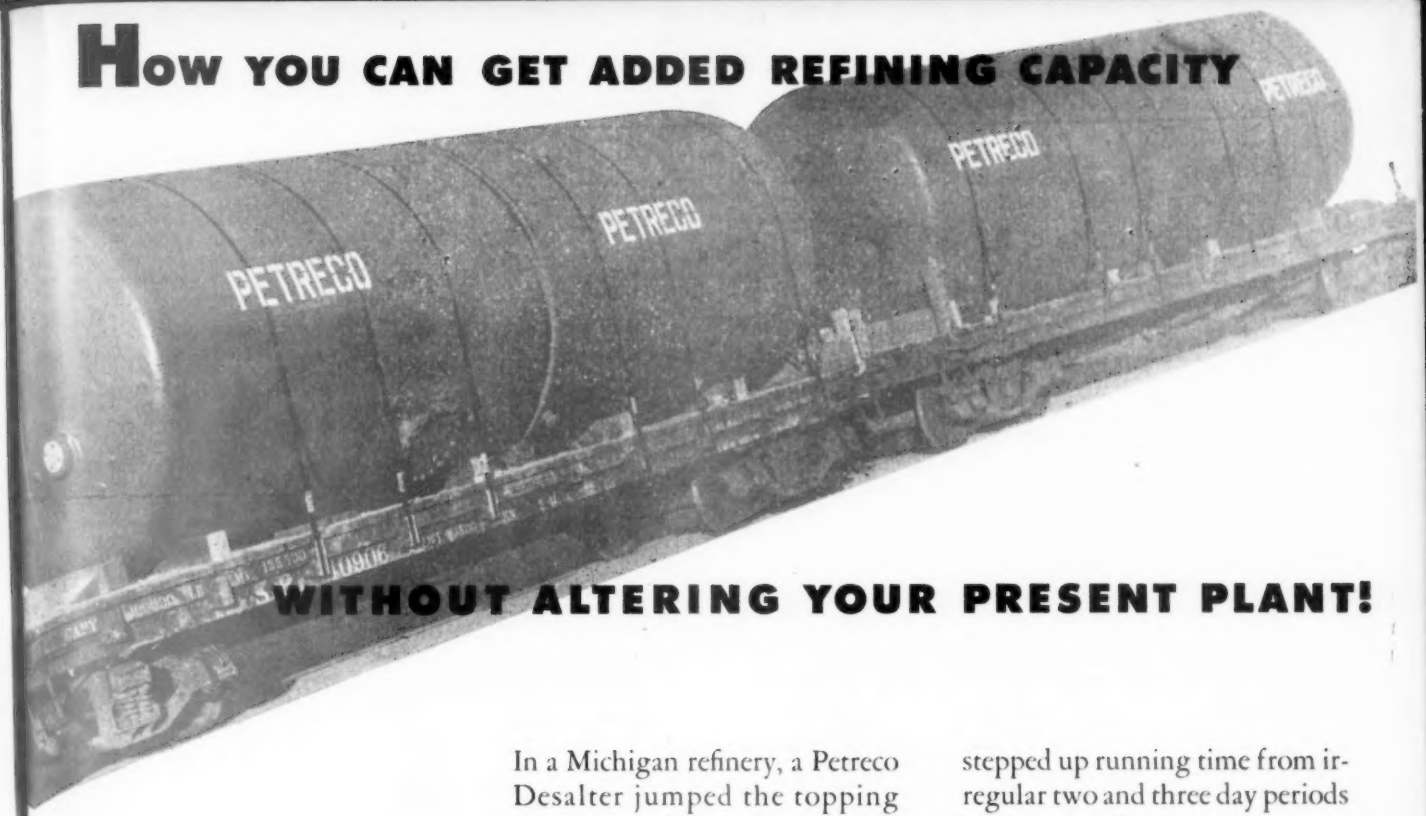

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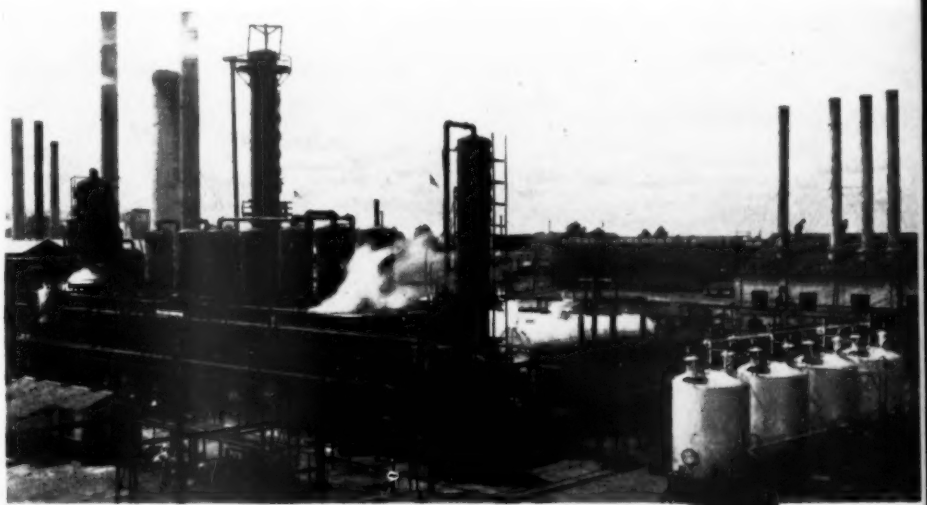

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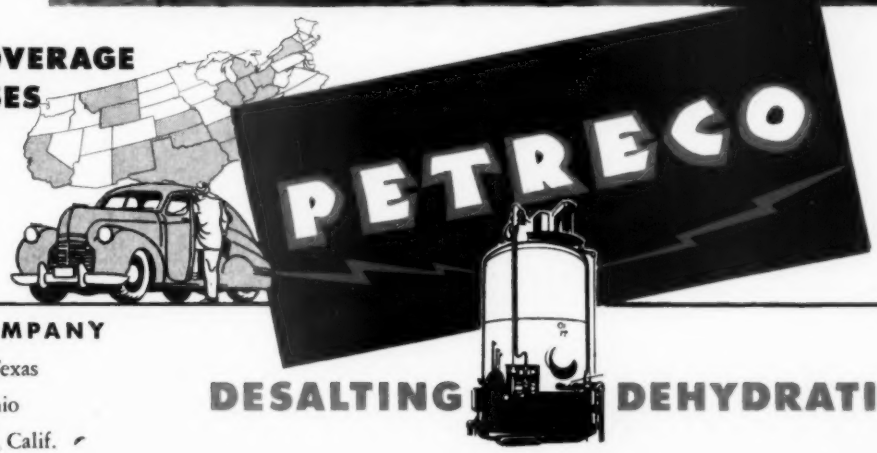

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arises before amyl nitrate can be made available in commercial quantities.

Acknowledgments

By way of acknowledgment, the authors wish to thank the following individuals and organizations for permission to use their data and assistance in preparing the manuscript:

Caterpillar Tractor Co., Peoria, Ill.—data.

Fisher, D. E., Universal Oil Products Co.—Literature search preparation and editorial comments.

Hinds, G. E. and Hunt, C., Sharples Chemicals, Inc.—Data.

Hubner, W. H., Ethyl Corp.—Data.

Nichols, R. M., Universal Oil Products Co.—Preparation of curves.

Robertson, A. F., Fairbanks-Morse & Co. (Formerly of the University of Wisconsin)—Data.

Sharples Chemicals, Inc.—Permission to use data.

Smith, M. A., Universal Oil Products Co.—Engine tests and assembly of data.

Universal Oil Products Co.—Permission to publish this paper.

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TABLE XI—Laboratory Inspection Data Straight-Run and Cracked Mid-Continent Gas Oil to Which Commercial Amyl-Nitrate Has Been Added

Fuel No.	% Amyl Nitrate	Vis. @ 100°F. S.S.U.	Grav. at 60°F. A.P.I.	Conradson Carbon % by Wt.	Flash Point (PM) °F.	I.B.P.	E.P.	Cetane No. Delay	Aniline Point °F.	Diesel Index No.	Higher Heating Value BTU/Lb.
1*	0	34	28.3	0.007	188	374	610	36.3	102.0	28.9	19,070
1a	1	34	28.1	0.094	182	243	610	46.0	....	....	19,000
1b	2	34	27.8	0.210	174	240	610	52.0	....	....	18,930
1c	3	34	27.7	0.290	172	260	612	57.0	....	....	18,840
2**	0	36	38.1	0.010	170	374	669	55.0	161.2	61.4	19,770
2a	1	36	37.6	0.053	168	266	669	68.9	....	....	19,650
2b	2	36	37.6	0.074	164	260	666	75.5	....	....	19,600
2c	3	35	37.5	0.090	158	254	666	80.5	....	....	19,500
Amyl Nitrate	..	28	11.4	....	...	293	337	...	....	...	11,270

NOTES:

* Fuel No. 1 is a Cracked Mid-Continent Gas Oil.

** Fuel No. 2 is a Straight-Run Mid-Continent Gas Oil.

This table was taken from a thesis by Dr. A. F. Robertson—see Bibliography (No. 7).

TABLE XII — Cetane Response for Addition of Amyl Nitrates to Distillate Fuels from U. S. Crude Sources

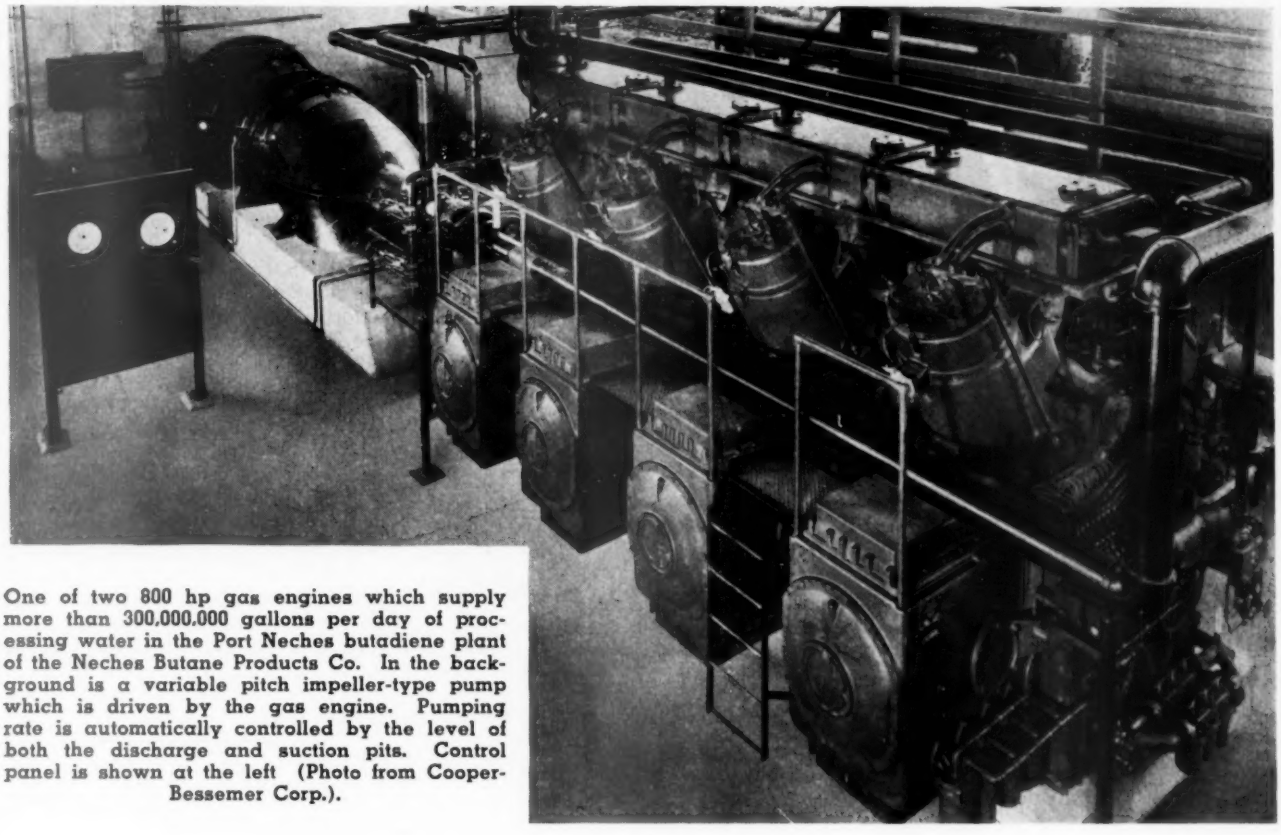
	Amyl Nitrate, In %		Cetane Number					Increase in Cetane Number (From Curve)						
	Str-Run	Cracked	0	0.5	1.0	2.0	3.0	0 to 0.5	0.5 to 1.0	1.0 to 1.5	1.5 to 2.0	2.0 to 2.5	2.5 to 3.0	Ref.*
1. Reference Fuel			74	82	90	100+	..	8.0	8.0	8.0	8.0	..	..	a
2. Pennsylvania	X		61	72	76	83	90	11.0	4.0	3.5	3.5	3.5	3.5	7
3. East Texas	X		58	67	71	78	82	8.5	5.0	3.5	3.0	2.2	1.8	7
4. Michigan	X		57	70	76	81	..	13.2	6.0	2.8	2.2	2.0	..	b
5. Diesel Fuel			56	62	68	72	..	6.5	5.5	3.0	1.0	0.7	..	a
6. Mid-Continent	X		55	63	69	76	81	8.3	5.7	4.0	3.0	2.5	2.5	11
7. Mid-Continent	X		54	67	69	..	..	14.0	2.0	2.0	..	..	..	a
8. Mid-Continent	X		54	65	70	73	..	11.0	5.0	2.0	1.0	..	..	b
9. Mid-Continent	X		53	..	66	..	..	7.0	6.0	..	..	..	..	b
10. Mid-Continent	X		50	57	63	69	74	7.0	5.5	3.8	3.0	2.5	2.2	5 & 7
11. Wyoming	X		50	..	65	..	..	8.8	6.2	..	..	..	..	b
12. Kerosine			49	54	56	60	61	4.4	3.4	2.0	1.2	0.7	0.3	a
13. Diesel Fuel			48	53	56	59	61	5.0	3.0	1.7	1.3	1.1	0.9	a
14. Furnace Oil			48	56	62	71	79	8.0	6.0	4.6	4.4	4.0	4.0	a
15. West Texas	X		47	52	58	64	73	5.6	4.7	4.3	3.9	3.8	3.7	7
16. California	X		44	52	54	60	..	5.5	4.5	3.7	2.3	..	..	a
17. Mid-Cont. Blend	50%	50%	43	51	56	..	..	8.0	5.0	..	..	..	..	b
18. Pennsylvania		X	42	50	56	64	66	8.0	6.0	4.6	3.4	1.3	0.7	7
19. California	X		41	47	52	59	63	6.0	5.0	4.0	3.0	2.3	1.7	7
20. California	X		40	49	53	56	..	9.0	4.0	1.8	1.2	0.8	..	a
21. E. & W. Texas		X	38	44	50	57	62	6.0	5.5	4.3	3.2	2.6	2.4	7
22. Gas Oil		X	38	45	48	60	..	6.5	5.7	5.3	4.5	..	..	a
23. Mid-Continent		X	36	42	46	52	57	7.0	4.2	3.1	2.8	2.6	2.3	11
24. Pennsylvania		X	35	45	51	58	..	10.5	5.0	4.0	3.5	..	..	12-IX
25. East Texas		X	34	42	46	49	..	6.0	5.0	2.5	1.5	1.3	..	a
26. Mid-Continent		X	33	38	42	49	54	4.7	4.3	4.0	3.0	2.7	2.3	6 & 7
27. California		X	33	39	44	49	54	6.0	5.0	3.0	2.5	2.1	1.9	7
28. Mid-Continent		X	32	40	42	49	..	6.8	4.7	3.0	2.5	1.9	..	12-IX
29. Mid-Continent		X	28	..	45	..	..	10.0	7.0	..	..	..	..	a
30. Illinois		X	26	32	36	41	46	6.0	3.8	3.1	2.6	2.5	2.0	12-IX

* Numbers in reference column refer to tables in this paper for which isoamyl nitrate was used. All other data are for commercial amyl nitrate. 12-IX refers to Table IX in Bibliography Reference No. 12.

a Data furnished by Sharples Chemicals, Inc., Philadelphia. (12-6-38).

b Data furnished by Sinclair Refining Co., East Chicago, Ind. (3-23-39).

Powers Pumps Supplying 300,000,000 Gallons of Water at Port Neches Butadiene Plant



One of two 800 hp gas engines which supply more than 300,000,000 gallons per day of processing water in the Port Neches butadiene plant of the Neches Butane Products Co. In the background is a variable pitch impeller-type pump which is driven by the gas engine. Pumping rate is automatically controlled by the level of both the discharge and suction pits. Control panel is shown at the left (Photo from Cooper-Bessemer Corp.).

Gas Engines in Unusual Service In Process Water Supply System

IN ANY process plant, a reliable water supply is of critical importance. The Neches river is the source of water for the Neches Butane Products Co. butadiene plant at Port Neches, Texas. Two 800-hp. Cooper-Bessemer Type G-MV gas engines are directly connected to variable pitch impeller-type pumps which supply more than 300,000,000 gallons per day to the main pump discharge pit. From here the water flows through large ducts more than 6000 feet to the pump suction pit. Ten 24,000-gallon-per-minute centrifugal pumps supply the water from this common source for the cooling and condensing needs of the various units of the plant.

A satisfactory water level must be maintained in the pump suction pit at all times and under variable demands. However, there is a considerable time interval before a change of level at the pump suction pit affects the level of the main pump discharge pit near the two main pumps. Control of the pumping rate of the variable pitch pumps from the level of either pit alone is impractical. If the main pump discharge pit level alone were the basis of controlling the main water pumping rate, the controller would have to be extremely sensitive to correct for a sudden increase in demand which would rapidly lower the water in the pump suction pit toward the minimum safe level before more than a slight change of level was reflected at the main pump discharge pit. Such a sensitive control would result in a continually changing pumping rate for the two main pumps, and the usual difficulty of "hunting" or pulsating control.

On the other hand, if the pump suction pit level alone were the basis of control, the controller would have to be set quite insensitive because of the time lag between a change in the pumping rate of the main pumps and the resulting change in level at the pump suction pit. Sensitive control at the pump suction pit would result in wide variation of level and possible overflow at the main pump discharge pit. And a control rate at the pump suction pit which would be insensitive enough to prevent overflowing at the main discharge pit would also allow the level at the pump suction pit to become dangerously low on rapidly increasing water demand.

The method chosen to solve the problem was to use level control at each pit. The primary level control is at the main pump discharge pit. The pumping rate is changed to maintain whatever level is required by the main pump discharge pit level controller. This controller is not set to maintain a fixed level; however, a secondary level controller at the pump suction pit adjusts (by telemeter system) the level control point of the main pump discharge pit level controller. Thus a slight lowering of the level in the pump suction pit instantly and automatically raises the level control point of the main pump discharge level controller which, in turn, increases the pumping rate until the higher level is reached at the main pump discharge rate. This provides immediate response, safety of level in each pit, and the proper sensitivity and reset rate for each controller.

The pumping rate is changed by adjusting the pitch of the impeller blades of the pump and by changing the speed of the driving engines from 225 to 325 rpm. At lower capacity all adjustment is made with the impeller pitch variation at minimum engine speed until maximum impeller pitch is obtained. On increasing demand, the engine speed is increased to a maximum of 325 rpm. However, as the engine speed is increased, the impeller pitch is reduced to keep within the horsepower rating of the engines. The rate of reduction of impeller pitch with increased engine speed is dependent on the level of the Neches river, and is adjustable for seasonal variation.

The level controllers are pneumatic

Pump motor lever and other controls for automatically regulating the pitch of the blades of the impeller-type pump (Photo from Cooper-Bessemer Corp.)

pressure controllers employing the air bubbler system for level detection. An electric telemeter system is used to transmit the level indication from the pump suction pit to the main pump discharge pit. Electric motors are used to change the pump impeller pitch, with a pneumatic motor lever to set the electric motor position. The pneumatic motor lever for the impeller pitch control and a similar motor lever for engine speed control are each regulated by the pneumatic main pump discharge pit controller. Manual control of the level at the pump suction pit, at the main pump discharge pit, or of the impeller pitch or engine speed alone is provided.

Another unusual requirement is that these engines must operate at all times under highly variable demands, much of the time at extremely light loads. This is possible through several unique features inherent in design, such as the type of gas injection and scavenging.

Furthermore, this application is unusual in that criticals throughout the variable speed range must be virtually non-existent for satisfactory operation of this type pump. The G-MV engines meet this requirement because they are designed normally for wide ranges of speed in other applications. Continuity of operation is another feature of these engines since they were developed to meet many phases of continuous process work.

NEW BOOKS FOR THE REFINER

Organic Chemistry Text Reprinted for 8th Time

Acceptance of *"Organic Chemistry"*, by Frank C. Whitmore, as a standard working tool in the technical man's library seems to be indicated by the fact that the eighth printing of this text has just come out. The book was originally published in 1937.

The work is designed, according to the author, as a one-volume reference text for practicing organic chemists and others who have to take occasional cognizance of organic compounds and their reactions. Mr. Whitmore is research professor of organic chemistry at Pennsylvania State College.

A copious index, including 49,000 entries and covering 122 pages, makes it easy to locate desired information; the total work covers 1080 pages. Copies of "Organic Chemistry" may be purchased through the Book Department of National Petroleum News, 1213 West Third Street, Cleveland 13, for $7.50.

° ° °

Chemistry of Synthetic Polymers is Described

"Synthetic Resins and Rubbers", by Paul O. Powers, describes the chemistry of these man-made polymers and of the raw materials which go into their manufacture. The book covers the principles of formation of synthetic resins and rubbers, production and reaction procedures, and applications and uses.

Mr. Powers, chief of organic research for the Armstrong Cork Co., treats his subject pretty much from a strictly chemical viewpoint, and resorts to liberal use of structural formulae to illustrate the discussion. Anyone not on intimate speaking terms with organic chemistry or armed with a good dictionary of chemical terminology might soon get lost. The author, assuming (probably quite correctly) that his readers would be for the most part practicing chemists in the field, or those familiar with the terms used has made little effort to define or explain them.

In discussing raw materials, the author points out that "petroleum is becoming more widely used as a source of raw materials for synthetic resins and synthetic rubbers." The petroleum chemist interested in learning more about this relatively new and growing field for materials he supplies will find a wealth of chemical information in the 296 pages of "Synthetic Resins and Rubbers."

Copies may be obtained through the Book Department of National Petroleum News, 1213 West Third Street, Cleveland 13, for $3.00.

° ° °

Lubrication Methods In Metal Cutting Field

"Lubricants and Cutting Oils for Machine Tools", by William G. Forbes, explains the fundamental principles of lubrication in relation to metal cutting and the application of various types of cutting oils to machine tool operations.

For anyone concerned with solving lubrication problems in the metal cutting field, including the manufacture or recommendation of suitable lubricants and oils, this text will prove extremely educational. Although compact (90 pages), it leaves one with a clear picture of this use of petroleum products.

Mr. Forbes discusses the various properties of lubricating and machine oils, their relative importance, and methods of testing; suggested points to be covered when specifying lubricating and cutting oils are also given. Different types of machine tools are explained, and the principles of machine tool lubrication discussed from the viewpoint of practical maintenance. The composition, compounds and blends, and practical application of cutting oils are covered in detail.

Other chapters deal with lubricating greases, mechanics of metal cutting, and treatment and prevention of skin diseases that result from contact with lubricants.

The text is well written and clearly illustrated. Copies of "Lubricants and Cutting Oils for Machine Tools" may be obtained from the Book Department of NATIONAL PETROLEUM NEWS, 1213 West Third St., Cleveland 13, for $1.50.

Aniline Points of Hydrocarbons*

Bureau of Mines Studies Show New Relationship Between "Aniline Function" and Critical Solution Temperature with Molecular Weight

The aniline point of hydrocarbons, the lowest temperature at which equal volumes of hydrocarbon and aniline are completely miscible, has been used for many years in the analysis of low-boiling compounds in the gasoline range and in the study of lubricating oil fractions. However, there is considerable confusion in the literature between aniline points and critical solution temperatures in aniline. Discrepancies in both values as reported by different investigators are not uncommon.

An extensive survey of the literature has been made by the U. S. Bureau of Mines to determine the best value for both aniline point and critical solution temperature. In addition, a new relationship has been determined, the "aniline function", which is a correlation of aniline point and critical solution temperature with molecular weight. It can be used in the selection of data and detection of errors in published or determined values, or in calculating boiling points of compounds whose boiling points cannot be experimentally determined but whose critical solution temperatures can be. Those portions of the report most informative to the oil industry are presented here.

*By John S. Ball***

THERE IS SOME confusion in the literature between the terms "aniline point" and "critical solution temperature in aniline". Aniline point refers specifically to the solution temperature, or lowest temperature of complete miscibility, of equal volumes of hydrocarbon and aniline. Critical solution temperature in aniline refers to the maximum solution temperature of the system hydrocarbon-aniline, regardless of the relative proportions. Thus, if the solution temperature, or lowest temperature of complete miscibility, is plotted against the composition of the hydrocarbon-aniline mixture, the highest point on the curve represents the critical solution temperature. As these curves are fairly flat over considerable ranges of composition, the aniline point in many instances differs little from the critical solution temperature.

Table 1 compares these two values for a number of hydrocarbons. As may be noted, the lower-molecular-weight members of the normal paraffin series show the greatest differences between aniline point and critical solution temperature, while those of higher molecular weight show no difference. There are indications that this relationship holds for other hydrocarbon series as well, but reliable data are too meager for proof.

The literature contains numerous data on both critical solution temperatures in aniline and aniline points of hydrocarbons. Published values vary considerably. Earlier results showed discrepancies, as might be expected, probably because of impurities either in the hydrocarbon or in the aniline. Water in the aniline has been pointed out as a source of error.[1] Many of these data have been assembled*** and an attempt has been made to select the best value from each set of data by comparing results obtained by different experimenters and by correlating the data for different members of a hydrocarbon series or family.

As data on many compounds are meager for both aniline point and critical solution temperature, knowledge concerning the relationships between the two properties aids considerably in their evaluations. By definition the aniline point cannot be greater than the critical solution temperature in aniline. As pointed out in the preceding section, the lower-molecular-weight hydrocarbons show the greatest differences be-

*Reprinted from Bureau of Mines Report of Investigations 3721

**Assistant Chemist, Bureau of Mines, Laramie, Wyo.

***—Given in Appendix to U. S. Bureau Report of Investigations 3721.

Table 1

Comparison of Aniline Points and Critical Solution Temperatures for some hydrocarbons*

	Aniline point, °C	C.S.T. in Aniline, °C	Diff.
n-Butane	83.1	84.1	1.0
n-Pentane	70.7	71.7	1.0
n-Hexane	68.6	69.1	.5
n-Heptane	69.7	70.1	.4
n-Octane	71.7	72.0	.3
n-Nonane	74.4	74.5	.1
n-Decane	77.5	77.5	.0
n-Undecane	80.6	80.6	.0
n-Dodecane	83.7	83.7	.0
2-Methylpropane	107.6	109.0	1.4
2-Methylhexane	72.8	73.6	.8
2-Methylpropene	14.9	15.8	.9
Cyclohexane	30.2	30.7	.5
Ethylcyclohexane	43.8	44.1	.3

*Values are best values as obtained from the literature.

TABLE 2—Aniline Points and Critical Solution Temperatures in Aniline

Hydrocarbon		Boiling point, °C. at 760 mm. Found	Boiling point, °C. at 760 mm. Literature	Density, d_4^{20} Found	Density, d_4^{20} Literature	Refractive index, n_D^{20} Found	Refractive index, n_D^{20} Literature	Aniline point, °C. Found§	Critical solution temperature in aniline, °C. Found§
Caprylene†	cis	. . .	124.6	.	0.72287	. . .	1.41391	*E33.4	*E33.4
		124.5	. . .	0.7203	. . .	1.41351	. . .	34.4	34.4
		124.1	. . .	.7196	. . .	1.41337	. . .	35.0	35.0
		124.0	.	.7195	.	1.41331	. .	35.2	35.3
	trans	. . .	123.35	.	.71842	. . .	1.41281	*E36.1	*E36.2
Cyclohexane		80.5	80.81	.7787	.7783	1.42598	1.4260	29.5	29.8
Decalin‡	cis	. . .	194.6	.	.8963	. . .	1.48113	*E30.3	*E30.3
		193.2	. . .	.8910	. . .	1.47942	. . .	34.4	34.4
		192.8	. . .	.8890	. . .	1.47826	. . .	35.0	35.0
		192.6	. . .	.8867	.	1.47716	. . .	35.2	35.3
	trans	.	185.5	.	.8699	.	1.46968	*E39.4	*E39.5
Dicyclohexyl		238.2	238.9	.8853	.8848	1.47950	1.4795	47.6	47.7
Diisobutylene**		102.1	101.2(A)	.7165	.7151(A)	1.4086	1.4082(A)	42.3	. . .
		. . .	104.5(B)	.	.7211(B)	.	1.4158(B)	.	.
n-Heptane		98.2	98.424	.6831	.68368	1.38761	1.38764	68.9	69.3
Methylcyclohexane		101.0	100.87	.7687	.7689	1.42282	1.4231	39.4	39.6
2,2,4-Trimethylpentane		99.2	99.233	.6919	.69189	1.39135	1.39155	79.8	79.8

§Literature values as given in appendix.
†Mixture of cis- and trans-octene-2.
‡Estimated values—extrapolated from determinations on mixtures of cis and trans isomers.
*Mixture of cis- and trans-decahydronaphthalenes.
**Mixture of 2,4,4-trimethylpentene-1 (A) and 2,4,4-trimethylpentene-2 (B) in ratio 3.7 to 1.

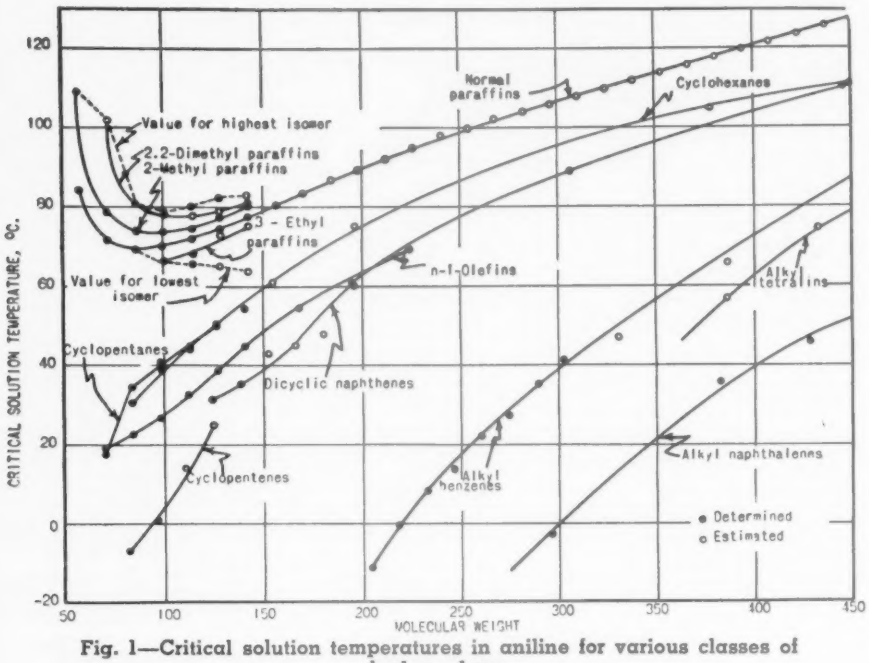


Fig. 1—Critical solution temperatures in aniline for various classes of hydrocarbons

tween the two values, while the compounds of higher molecular weight show decreasing differences. Only a few data are available that give both critical solution temperature and aniline point on the same hydrocarbon sample.

To help establish the relationship between these properties, both were determined on a number of compounds (Table 2) of varying degrees of purity. Even though the compound was not very pure, as n-heptane, the difference between critical solution temperature and aniline point agreed with that in Table 1, which is based on some of the more reliable aniline-point and C.S.T. data. The differences between the values for the two properties have been given some weight in selecting best values. However in some instances (for example, methylcyclohexane) it was impossible to obtain best values from published values that showed the proper differences.

The results shown in Table 2 for aniline point and critical solution temperature have been listed*** and considered in the selection of best values only when the purity of the compound was high. The aniline point was determined by A.S.T.M. method D 611-41T[3] except that 5 ml. of compound and 5 ml. of aniline were used instead of the specified 10 ml. The critical solution temperature in aniline was determined by varying the volume of compound added until a maximum solution temperature was found.

Stereoisomers have critical solution temperatures which are often as much as 5° apart. Considerable data giving aniline points or critical solution temperatures have been published for mixtures of the two forms. The best values were not selected from these data because of the possible variations in the compositions of the mixtures.

Seyer and Walker[3] state that density and refractive index follow a straight-line relationship with concentration for mixtures of cis— and trans-decahydronaphthalene. For mixtures of compounds whose aniline points are not widely separated aniline points are also a linear function with concentration. This relationship (Table 10) is discussed under mixed aniline points in the section on Aniline Points of Aromatic Hydrocarbons. Thus, it should be possible to obtain data from a relatively inefficient fractionation that could be extrapolated to give aniline points of pure components. A sample of decahydronaphthalene was treated with sulfuric acid and distilled to remove material boiling outside the range of the stereoisomers. The material within the boiling range was fractionated into three cuts, and the properties were determined as shown in Table 2. The aniline points and critical solution temperatures in aniline of the pure stereoisomers were estimated by extrapolation. A similar procedure (without acid treatment) was carried out on caprylene.

Aniline points have been shown to be related to other physical properties. Francis[4] has pointed out that for each group of paraffin isomers, aniline points have a linear relationship with either refractive index or specific gravity. He also has suggested a correlation between octane number, boiling point and aniline point for paraffins. He found that the sum of the boiling point and aniline point in degrees Centrigrade when plotted against octane number gave a straight line for each group of isomers. Vlugter, Waterman, and Van Westen[5] have shown a relationship between specific refraction, aniline point, and molecular weight. Critical solution temperatures* of hydrocarbons plotted against molecular weight (Fig. 1) reveal a number of regularities but none pronounced enough to place the study on a systematic basis.

According to Van der Wall's theory of corresponding states,[6] properties of

*Critical solution temperatures are used rather than aniline points because of the greater number of reliable data.

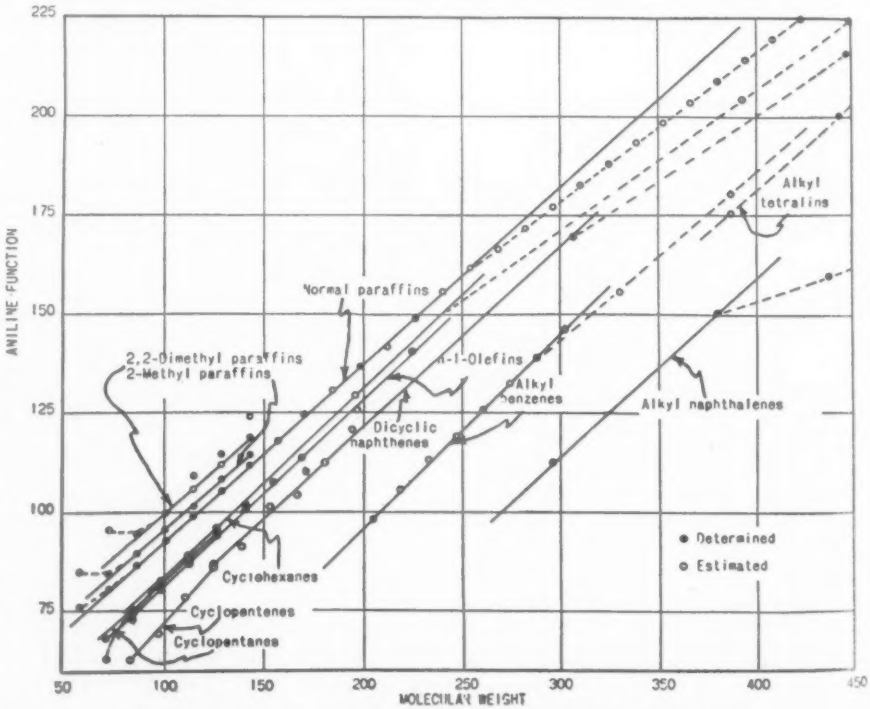


Fig. 2—Aniline functions for various classes of hydrocarbons

***Given in Appendix to U. S. Bureau Report of Investigations 3721.

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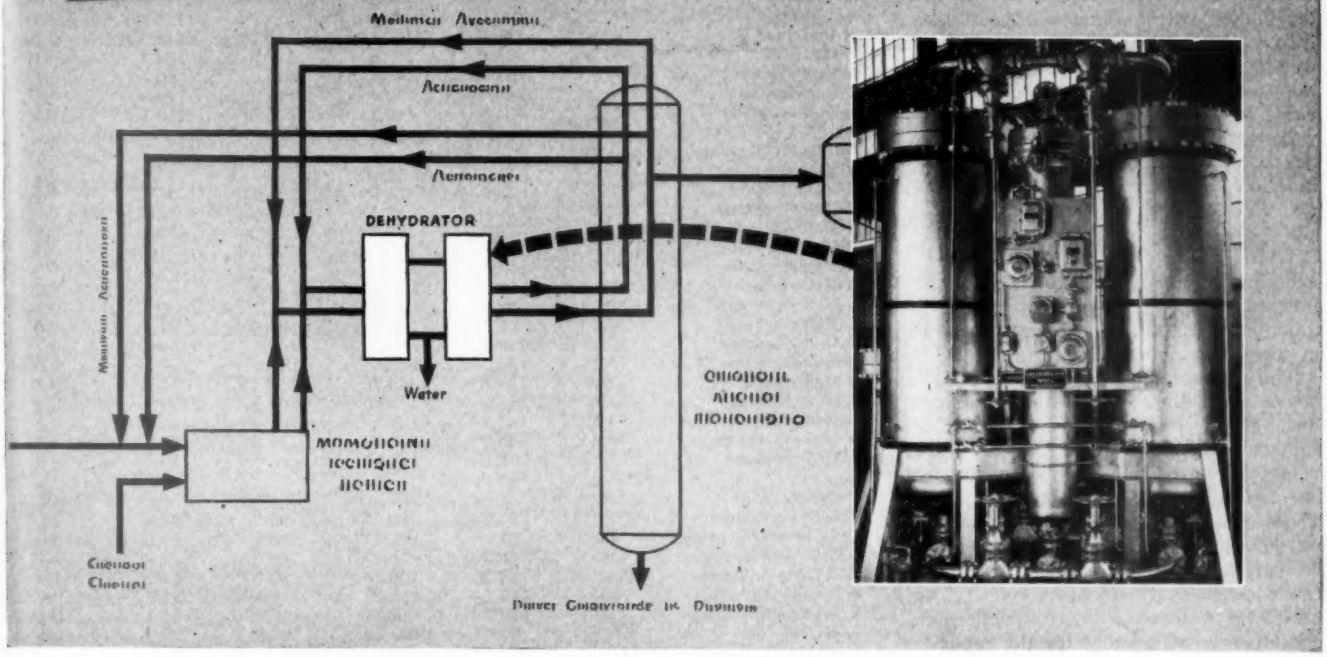

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liquids should be compared at equal fractions of their critical temperatures. It seems reasonable that the fraction of the critical temperature of a hydrocarbon at which the hydrocarbon becomes miscible with a solvent such as aniline should be a function of molecular structure. As critical temperatures have not been determined for many hydrocarbons, the boiling point, which is approximately two-thirds the critical temperature, was used. This fraction, critical solution temperature in degrees Kelvin divided by boiling point in the same units, was found to be proportional to the reciprocal of the molecular weight. The function

$$\frac{\text{C.S.T. in °K.}}{\text{B.P. in °K.}} \times \text{molecular weight}$$

exhibited quite remarkable regularity for each type of hydrocarbon. This function is denoted as "aniline function" in the following discussion.

The regularity of the aniline function becomes apparent when these functions for various hydrocarbons are plotted against molecular weights (Fig. 2). The values for n-paraffins form a straight line, except for the first two members. Those for the iso-paraffins form a straight line which is above that for normal compounds; other branched-chain series show similar results. The 1-n-olefin values form a straight line considerably below that for the n-paraffins, while the cyclohexane data fall very close to this line, which is almost parallel to the normal paraffin line. The data on aromatics are meager, but they indicate that the points for these compounds form a straight line below and parallel to the others. The deviation in the case of aniline functions with higher values (indicated by dotted lines) are discussed later. The estimated results of aniline function include those for which the boiling point as well as those for which the critical solution temperature, were calculated.

The many regularities justify closer examination of the function. Results for various series of hydrocarbons are given in Tables 3 to 6. The most striking regularity about the function is the increase of approximately 6.3 units for each CH_2 group added. This holds not only in the paraffin series but also in the olefin and naphthene series, except when the added CH_2 forms on additional methyl group. These regularities can be described most readily by presentation of methods for calculating the function. Calculated results by these methods are compared with results from actual data in Tables 3 to 6.

Calculation of aniline function for paraffins. — The aniline function for straight-chain paraffin hydrocarbons may be calculated by the formula

$$48.5+6.3n,$$

where n is the number of carbon atoms in the compound. This value must be modified for very short chains or for branched chains by the following rules:

1. If the longest carbon chain has only

TABLE 3—Values of Aniline Function for Paraffins

Compound	CST in aniline, °C.*	Boiling Point °C.	Molec. weight, 1941	—Aniline function— From Data	Calc.†	Dev.
Normal paraffins						
n-Butane	84.1	−0.5	58.12	76.2	76.2	0.0
n-Pentane	71.7	36.1	72.15	80.5	80.5	0.0
n-Hexane	69.1	68.7	86.17	86.3	86.3	0.0
n-Heptane	70.1	98.4	100.20	92.6	92.6	0.0
n-Octane	72.0	125.6	114.22	98.9	98.9	0.0
n-Nonane	74.5	150.7	128.25	105.2	105.2	0.0
n-Decane	77.5	174.0	142.28	111.6	111.5	−0.1
n-Undecane	80.6	195.8	156.30	117.9	117.8	−0.1
n-Dodecane	83.7	216.2	170.33	124.2	124.1	−0.1
n-Tetradecane	89.5	253.6	198.38	136.6	136.7	+0.1
n-Hexadecane	95	286.6	226.43	148.9	149.3	+0.4
n-Dotriacontane	127.5	494.5	448.83	234.2	250.1	+15.9
Mono-methylparaffins						
2-Methylpropane	109.0	−11.7	58.12	85.0	85.0	0.0
2-Methylbutane	78.9	28.0	72.15	84.3	84.3	0.0
2-Methylpentane	73.9	60.3	86.17	89.7	89.6	−0.1
2-Methylhexane	73.6	90.1	100.20	95.6	95.4	−0.2
2-Methylheptane	74.5	117.7	114.22	101.6	101.7	+0.1
2-Methyloctane	77.5	143.2	128.25	108.0	108.0	0.0
2-Methylnonane	80.3	166.8	142.28	114.3	114.3	0.0
3-Methylpentane	69.3	63.2	86.17	87.7	88.6	+0.9
3-Methylhexane	70.6	91.9	100.20	94.4	94.4	0.0
3-Methylheptane	72.2	119.1	114.22	100.6	100.7	+0.1
3-Methyloctane	75.0	144.2	128.25	107.0	107.0	0.0
3-Methylnonane	78.3	167.8	142.28	113.4	113.3	−0.1
4-Methylheptane	71.6	117.5	114.22	100.8	101.4	+0.6
4-Methyloctane	74.5	142.5	128.25	107.3	107.7	+0.4
4-Methylnonane	78.3	165.7	142.28	113.9	114.0	+0.1
5-Methylnonane	77.9	165.1	142.28	114.0	114.0	0.0
Dimethylparaffins						
2, 2-Dimethylbutane	81.0	49.7	86.17	94.5	92.4	−2.1
2, 2-Dimethylpentane	78.0	79.2	100.20	99.9	99.9	0.0
2, 3-Dimethylbutane	71.9	58.0	86.17	89.8	89.9	+0.1
2, 3-Dimethylpentane	68.0	79.2	100.20	97.0	95.2	−1.8
2, 3-Dimethylhexane	70.6	115.7	114.22	101.0	101.0	0.0
2, 3-Dimethylheptane	73.2	140.7	128.25	107.3	107.3	0.0
2, 4-Dimethylpentane	78.7	80.7	100.20	99.6	98.7	−0.9
2, 4-Dimethylhexane	76.0	109.8	114.22	104.1	103.5	−0.6
2, 5-Dimethylhexane	77.8	109.3	114.22	104.8	104.5	−0.3
2, 6-Dimethylheptane	80.0	135.2	128.25	110.9	110.8	−0.1
3, 3-Dimethylpentane	70.3	86.0	100.20	95.8	96.7	+0.9
3, 4-Dimethylhexane	68.2	117.9	114.22	99.7	100.7	+1.0
Other paraffins						
2, 2, 3-Trimethylbutane	72.3	80.9	100.20	97.8	97.5	−0.3
2,2, 3-Trimethylpentane	70.7	109.8	114.22	102.6	103.0	+0.4
2, 3, 4-Trimethylpentane	68.7	113.5	114.22	101.0	101.8	+0.8
2, 2, 4-Trimethylpentane	80.0	99.2	114.22	108.3	109.0	+0.7
2, 3, 3-Trimethylpentane	67.0	115.1	114.22	100.1	100.8	+0.7
2, 2, 5-Trimethylhexane	82.7	124.1	128.25	114.9	114.8	−0.1
2, 2, 3, 3-Tetramethylbutane	74.8	106.5	114.22	104.7	98.6	−6.1
3-Ethylpentane	66.3	93.5	100.20	92.8	94.0	+2.1
3-Ethylhexane	68.7	118.7	114.22	99.6	100.7	+1.1
2-Methyl, 3-ethylpentane	67.2	115.7	114.22	100.0	98.5	−1.5
3-Methyl, 3-ethylpentane	65.9	118.4	114.22	98.9	103.0	+4.1

*Taken from "best value" column of appendix.
†From molecular structure as explained in text.

TABLE 4—Values of Aniline Function for Olefins

Compound	CST in aniline, °C.*	Boiling point, °C.	Molec. weight, 1941	—Aniline function— From data	Calculated†	Dev.
Straight-chain 1-olefins:						
1-Pentene	19.3	30.1	70.13	67.6	67.6	0.0
1-Hexene	22.9	63.7	84.16	74.2	74.0	— .2
1-Heptene	26.6	92.8	98.18	80.4	80.4	.0
1-Octene	32.8	121.6	112.21	87.0	86.8	— .2
1-Nonene	38.6	145.3	126.23	94.0	93.2	— .8
1-Decene	44.8	172.0	140.26	100.2	99.6	— .6
1-Dodecene	54.9	213.0	168.31	113.6	112.4	—1.2
1-Tetradecene	60.2	249	196.36	125.4	125.2	— .2
1-Hexadecene	69.4	274	224.42	140.5	138.0	—2.5
Branched-chain olefins:						
2-Methylpropene	15.8	—6.7	56.10	60.8	....	....
2-Methyl-2-butene	11.0	38.5	70.13	63.9	....	....
2-Methyl-2-pentene	24.0	67.4	84.16	73.4	....	....
2, 3, Trimethyl-1-butene	35.2	77.9	98.18	86.2	....	....
2, 4, 4-Trimethyl-2-pentene	32.2	104.5	112.21	90.7	....	....

*Values taken from "best value" column in appendix.
†From molecular structure as explained in text.

3 carbon atoms, add 8.8; if only 4 carbon atoms, add 2.5; if only 5 carbon atoms, add 0.5.

2. For the first branch chain in the 2-position (from either end of the longest carbon chain) add 2.8, and for the second add 4.0. For each branch chain in the 3-position add 1.8. For every other branch chain add 2.5. When a branch chain may be counted either in the 3-position or some other the value is taken for the 3-position.

3. When branch chains are on adjacent carbon atoms, subtract 2.5.

Calculation of aniline function for olefins.—The aniline function for straight-chain olefins with the double bond in the end position is calculated by

$$35.6+6.4n,$$

where n is the number of carbon atoms in the compound.

Calculation of aniline function for naphthenes.—The aniline function may be calculated for naphthenes from the following equations:

For compounds with 5-member rings,

$$63.3+11.7+6.4\ (n-b),$$

For compounds with 6-member rings,

$$72.3+10.0+6.4\ (n-b),$$

where b is the number of side chains and n is the number of carbon atoms in the side chains. A correction of −2.5 is made for adjacent side chains.

Calculation of aniline function for aromatics.—The aniline function for benzene derivatives may be calculated from the expression

$$27.9+15.0\ b+6.9\ (n-b),$$

where b is the number of side chains and n is the number of carbon atoms in the side chains.

Comparison of calculated and experimental results.—Values of aniline function for various compounds as calculated by the methods just described are compared with results from actual experiment in Tables 3 to 6. Very close agreement between determined and calculated values for aniline function is shown by the lower members of the paraffin series. The values for the higher members become more discordant for two reasons: (1) Lack of accurate data in this range and (2) a systematic error, possibly due to the effect of the higher temperatures on aniline. The dielectric constant of aniline, which is virtually a straight-line function over the range 0-90°C.,[7] shows considerable curvature at higher temperatures. Calculation of the aniline functions of olefins, naphthenes and aromatics has been less satisfactory because of the lack of data. However, the information available permits some rather general conclusions regarding these types of compounds.

The aniline function appears to depend upon the carbon-hydrogen ratio to an even greater extent than does the critical solution temperature in aniline. Thus, the olefin and monocyclic naphthene lines in Fig. 2 are much closer together than in Fig. 1. This relationship is more evident in Table 7. The 8-carbon-atom compounds of varying hydrogen content indicate that the aniline function roughly is proportional to the amount of hydrogen in the molecule. Thus, the change from C_8H_{18} to C_8H_{16} reduces the aniline function from 10 to 12 units; the change from C_8H_{16} to C_8H_{14}, 20.8 units; and the change from C_8H_{18} to C_8H_{10}, 48.9 units. The critical solution temperature shows a much greater difference between the normal paraffin and olefin values than between the normal paraffin and the naphthene values.

Deanesly and Carleton[8] have specified the following conditions for a physical property to be additive: (1) The molecular value of the property (mole-

TABLE 5—Values of Aniline Function for Naphthenes

Compound	C.S.T. in aniline °C.*	Boiling point °C.†	Molec. weight, 1941	Aniline function From data	Aniline function Calculated‡	Dev.
Cyclobutanes:						
Ethylcyclobutane	38.6	70.7	70.13	64.1	....	....
Cyclopentanes:						
Cyclopentane	17.7	49.2	70.13	63.3	63.3	0.0
Methylcyclopentane	34.4	71.9	84.16	75.0	75.0	.0
Ethylcyclopentane	38.7	103.1	98.18	81.4	81.4	.0
n-Propylcyclopentane	45.0	130.8	112.21	88.4	87.8	− .6
n-Butylcyclopentane	50.0	157.2	126.23	94.9	94.2	— .7
1,2-Dimethylcyclopentane cis	39.6	99.3	98.18	82.4	84.2	+1.8
trans	47.0	91.9	98.18	86.1	84.2	−1.9
1-Methyl, 2-propylcyclopentane cis	52.5	152.5	126.23	96.6	97.0	+ .4
trans	58.0	146.3	126.23	99.7	97.0	−2.7
1,2-Diethylcyclopentane cis	50.9	152.5	126.23	96.1	97.0	+ .9
trans	56.6	146.3	126.23	99.2	97.0	−2.2
Cyclohexanes:						
Cyclohexane	30.7	80.8	84.16	72.2	72.3	+ .1
Methylcyclohexane	40.3	100.9	98.18	82.3	82.3	.0
Ethylcyclohexane	44.1	130.4	112.21	88.2	88.7	+ .5
n-Propylcyclohexane	§50.0	155.0	126.23	95.3	95.1	— .2
n-Butylcyclohexane	§54.7	179	140.26	101.7	101.5	− .2
1,1-Dimethylcyclohexane	45.4	119.8	112.21	90.7	92.3	+1.6
1,2-Dimethylcyclohexane cis	41.7	130.1	112.21	87.6	89.8	+2.2
trans	48.3	123.7	112.21	90.9	89.8	−1.1
1,3-Dimethylcyclohexane cis	46.3	124.7	112.21	90.1	92.3	+2.2
trans	51.7	120.7	112.21	92.5	92.3	— .2
1,4-Dimethylcyclohexane cis	46.9	124.5	112.21	90.3	92.3	+2.0
trans	52.7	119.6	112.21	93.1	92.3	— .8
Isopropylcyclohexane	48.9	154.4	126.23	95.1	95.1	.0
Hexamethylcyclohexane	65.5	212	168.31	117.5	117.3	— .2

*Taken from "best value" column in appendix.
†Doss, M. P., Physical Constants of the Principal Hydrocarbons: New York, 3d ed., 1942.
‡From molecular structure as explained in text.
§Aniline points.

TABLE 6—Values of Aniline Function for Aromatics

Compound	C.S.T. in aniline °C.*	Boiling point °C.	Molec. weight, 1941	Aniline function From data	Aniline function Calculated†	Dev.
Monoalkylbenzenes:						
1-Phenylnonane	—12.3	280.5	204.34	96.3	98.3	+2.0
2-Phenylnonane	—10.1	273	204.34	98.4	98.3	+ .3
2-Phenyldecane	— .6	289	218.37	105.9	105.2	− .7
2-Phenylundecane	8.1	305	232.39	113.0	112.1	— .9
2-Phenyldodecane	13.7	321	246.42	119.0	119.0	.0
2-Phenyltetradecane	27.3	350	274.47	132.3	132.8	+0.5
1-Phenylhexadecane	40.4	381	302.52	145.0	146.6	+1.6
2-Phenylhexadecane	41.1	378	302.52	146.0	146.6	+ .6
Polyalkylbenzenes:						
Diamylbenzene	16.5	264	218.37	117.7	113.5	—4.2
Diheptylbenzene	41.2	354	274.47	137.6	141.1	+3.5

*Taken from "best value" column in appendix.
†From molecular structure as explained in text.

TABLE 7—Aniline Functions and Critical Solution Temperatures of 8-Carbon Atom Compounds

Compound	Empirical formula	Aniline function	Difference from aniline function of n-hydrocarbon	Critical solution temp. in aniline °C.	Difference from C.S.T. of n-hydrocarbon
n-Octane	C_8H_{18}	98.9	...	72.0	...
n-1-Octene	C_8H_{16}	86.8	12.1	32.8	39.2
Propylcyclopentane	C_8H_{16}	88.4	10.5	45.0	27.0
Ethylcyclohexane	C_8H_{16}	87.9	11.0	44.1	27.9
Propylcyclopentene	C_8H_{14}	78.1	20.8	*14.2	58.0
Ethylbenzene	C_8H_{10}	†50.0	48.9	...	...

*Aniline point.
†Calculated by formula: 27.9+15.2b+6.9 (n-b). (See text).

TABLE 8—Comparison of Differences in Aniline Function and Heats of Isomerization for Various Isomers

	Heat of isomerization at 25° C. kg.-cal.	Aniline function	Aniline function difference from n-paraffin
n-Hexane	0.00	86.3	0.0
3-Methylentane	.76	87.7	1.4
2-Methylpentane	1.30	89.7	3.4
2,3-Dimethylbutane	1.96	89.8	3.5
2,2-Dimethylbutane	3.49	94.5	8.2
n-Heptane	.00	92.6	.0
3-Ethylpentane	.14	92.8	.2
3-Methylhexane	.72	94.4	1.8
2-Methylhexane	1.30	95.6	3.0
2,3-Dimethylpentane	2.18	97.0	4.4
3,3-Dimethylpentane	2.44	95.8	3.2
2,4-Dimethylpentane	2.54	99.6	7.0
2,2,3-Trimethylbutane	3.00	97.8	5.2
2,2-Dimethylpentane	3.42	99.9	7.3

TABLE 9—Mixed Aniline Points (with n-Heptane) of Various Compounds

Compound	Mixed Aniline Point °C.	Aniline Point °C.
Benzene	11.0	....
Toluene	10.0	....
Xylenes (mixed)	13.1	....
t-Butylbenzene	14.9	....
Phenylcyclohexane	11.9	....
Cyclohexene	28.6	....
Phenylacetylene	17.3	....
Styrene	10.0	....
Methylstyrene	11.0	....
Dipentene	33.8	....
Cyclohexane	48.7	29.6
Caprylene	51.3	31.8
Methylcyclohexane	54.4	39.5
Diisobutylene	56.6	42.3
n-Heptane	69.0	69.0

cular weight times value of property) for a hydrocarbon can be calculated from the number of carbon and hydrogen atoms, the number of rings, and the number of double bonds; (2) for a mixture the value of the property must be a weight average of the values for the individual components. If these conditions are met, the molecular value of the property is a function of the hydrogen content and the unsaturation.

The aniline function does not satisfy exactly the first condition because of the greater emphasis that the aniline function places on the arrangement of the atoms in the molecule. As has been pointed out, the aniline function depends largely upon the hydrogen content. These similarities to the first condition and to the resulting relationship suggest that the aniline function might be an additive property and that condition 2 (the value for a mixture being obtainable as a weight average of values for individual components) should hold. Investigation of this suggestion is described in the section on Aniline Points of Aromatic Hydrocarbons.

Among isomers of the paraffin series the aniline function is lowest for the normal or straight-chain compound. The order of increasing values in the hexane series is: Normal compound, 3-methyl compound, 2-methyl compound, 2, 3-dimethyl compound and 2, 2-dimethyl compound. This order is the same as that for their heats of isomerization;* a similar relationship holds for the heptanes. This comparison (Table 8) suggests that the vibrational energy of the hydrocarbon exerts a marked influence on solubility; it also indicates the influence of another factor which probably is the symmetry of the molecule.

Although the methods for calculating the aniline function of the paraffin hydrocarbons are highly empirical, they plainly indicate how variations in molecular structure affect it. Variations in isomers of a particular hydrocarbon may be attributed largely to interaction between or among the methyl groups. The distance over which such interaction can take place is apparently through a chain of 5 carbon atoms, and the shorter the chain the greater the effect. Methyl groups on adjacent carbon atoms (as in 3-methyl paraffins or 2,3-dimethyl paraffins, etc.) cause a characteristic lowering of the aniline function; this action seems to support the theory of hyperconjugation.[10] The lowering may be attributed to the formation of a conjugated system between the two methyl groups and an induced double bond between the adjacent carbon atoms. In 2-methyl-2-butene where the double bond is real the lowering is quite pronounced. It is somewhat less for 2-methyl-2-pentene which has one less methyl group in the conjugated system.

The aniline function has a number of possible uses. Perhaps the most evident is in the selection of data and detection of errors in published or determined values. Its use in estimating critical solution temperatures in aniline of hydrocarbons for which this property has not been determined is also evident. The aniline function was used for both these purposes in compiling the best values for the appendix. Another possible use is for calculating boiling points of compounds whose boiling points cannot be determined, but whose critical solution temperatures can be. The function also may prove valuable in the study of molecular structure.

This type of correlation raises questions concerning two types of hydrocarbons. There are no published data for critical solution temperatures or aniline points of the lower-boiling members of the aromatic series. Similar data concerning solid hydrocarbons are both meager and discordant. These two types of hydrocarbons therefore were studied by blending them with other types of hydrocarbons whose critical solution temperatures or aniline points are known.

Aniline points of highly aromatic compounds usually fall below 0°C.; n-nonylbenzene is the lowest member of the aromatic series whose C.S.T. in aniline has been measured. Because of these low temperatures direct determination of the aniline points of aromatic hydrocarbons or mixtures containing

TABLE 10—Calculation of Aniline Points of Mixtures by Various Methods

Mixture	Prop. by Vol.	Calculated Aniline Points: Vol. avg. of aniline pts.	Wght., avg. aniline pt. boiling pt.	Vol. avg. aniline pt. boiling pt.	Determ. aniline point
Caprylene methylcyclohexane (1) (2)	50:50	35.7	36.5	36.0	35.8
n-Heptane-caprylene (3)	75:25	59.7	59.9	60.5	60.4
Do	50:50	50.4	50.7	51.4	51.3
Do	25:75	41.1	41.2	41.8	42.0
n-Heptane-cyclohexane (4)	80:20	61.1	60.7	61.0	61.1
Do	60:40	53.2	52.2	52.9	53.1
Do	50:50	49.3	48.2	49.0	48.7
Do	40:60	45.4	44.4	45.0	44.8
Do	20:80	37.5	36.8	37.2	36.7
n-Heptane-decalin (5)	50:50	52 0	51.0	58.2	46.5
n-Heptane-dicyclohexyl (6)	50:50	58.3	60.2	68.6	58.1
n-Heptane-diisobutylene (7)	50:50	55.7	55.4	55.8	56.6
n-Heptane-isooctane (8)	50:50	74.4	74.4	74.4	74.2
n-Heptane-methylcyclohexane	50:50	54.3	53.3	54.3	54.4
Isooctane-cyclohexane	90:10	74.8	74.2	74.6	74.5
Do	80:20	69.8	68.8	69.5	69.6
Do	70:30	64.7	63.5	64.4	64.3
Do	60:40	59.7	58.6	59.2	58.4
Do	50:50	54.7	53.3	54.3	53.4
Do	40:60	49.7	48.3	49.2	48.5
Do	30:70	44.7	43.4	44.2	43.2
Do	20:80	39.6	38.6	39.3	38.2
Do	10:90	34.6	32.2	34.4	34.0

(1) Caprylene: Boiling point, 124.1°C.; d_4^{20}, 0.7196; aniline point, 31.8°C.
(2) Methylcyclohexane: Boiling point, 101.0°C.; d_4^{20}, 0.7687; aniline point, 39.5°C.
(3) n-Heptane: Boiling point, 98.2°C.; d_4^{20}, 0.6831; aniline point, 69.0°C.
(4) Cyclohexane: Boiling point, 80.5°C.; d_4^{20}, 0.7787; aniline point, 29.6°C.
(5) Decalin: Boiling point, 192.8°C.; d_4^{20}, 0.8890; aniline point, 35.0°C.
(6) Dicyclohexyl: Boiling point, 238.2°C.; d_4^{20}, 0.8853; aniline point, 47.6°C.
(7) Diisobutylene: Boiling point, 102.1°C.; d_4^{20}, 0.7165; aniline point, 42.3°C.
(8) Isooctane: Boiling point, 99.2°C.; d_4^{20}, 0.6919; aniline point, 79.8°C.

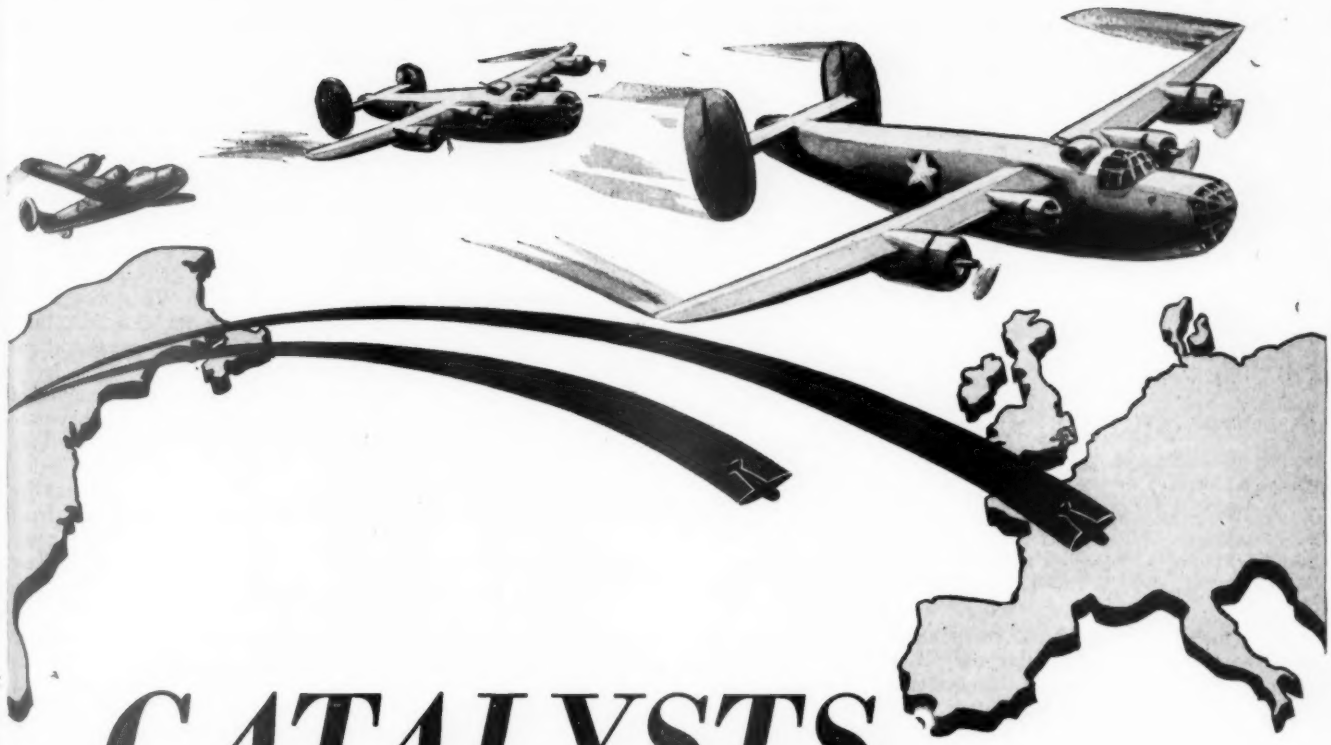

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TABLE 11—Calculated Aniline Points for Benzene

Diluent	Proportion by volume of benzene (1) diluent	Aniline point of mixture, °C.	Calculated aniline point °C. From vol. avg. of aniline points	From wght. avg of aniline point boiling point	From vol. avg. of aniline point boiling point
n-Heptane (2)	50:50	11.0	—47.0	—37.8	—44.5
n-Octane (3)	50:50	16.4	—39.6	—27.7	—34.3
Isooctane (4)	10:90	68.0	—42.7	—49.4	—37.1
Do	18:82	59.0	—38.0	—41.7	—33.5
Do	30:70	45.1	—37.0	—52.1	—35.8
Do	40:60	32.2	—40.0	—50.5	—31.0
Do	50:50	18.9	—42.5	—58.8	—39.7
Do	60:40	3.5	—47.7	—64.9	—45.0
Cyclohexane (5)	10:90	19.7	—69.4	—58.1	—67.9
Do	20:80	9.8	—69.4	—67.2	—68.9
Do	30:70	—.9	—72.1	—63.7	—71.6
Diisobutylene (6)	10:90	31.7	—73.7	—45.4	—59.1
Do	20:80	20.0	—69.2	—51.9	—64.8
Do	30:70	8.7	—69.7	—54.3	—65.9

(1) Benzene: Boiling point, 80.0°C.; d_4^{20}, 0.8777.
(2) n-Heptane: Boiling point, 98.2°C.; d_4^{20}, 0.6831; aniline point, 69.0°C.
(3) n-Octane: Boiling point, 125.6°C.; d_4^{20}, 0.7029; aniline point, 71.4°C.
(4) Isooctane: Boiling point, 99.2°C.; d_4^{20}, 0.6919; aniline point, 79.8°C.
(5) Cyclohexane: Boiling point, 80.5°C.; d_4^{20}, 0.7787; aniline point, 29.5°C.
(6) Diisobutylene: Boiling point, 102.1°C.; d_4^{20}, 0.7165; aniline point, 42.3°C.

large quantities of aromatic components is not convenient, and the use of a mixed aniline point has been suggested.[11] This method consists in determining the aniline point of a mixture of equal volumes of the material being tested and of a naphtha whose aniline point is 60.0°C. Because of possible variations in the composition of the naphtha and consequent unreliability of the test, Shoemaker and Bolt have proposed[12] that a further specification be placed on the naphtha, namely, that it give a specified mixed aniline point with c.p. toluene. The following table shows how variations in composition of the blending naphtha may affect aniline points:

Components of 60.0°C. Aniline point blend	Mixed Aniline Pt. (°C.) Benzene	Cyclohexane
Benzene, iso-octane	5.5	42.3
n-Heptane, methylcyclohexane	3.4	44.3

Gillam[13] suggests the use of a diluent composed of methylcyclohexane and n-heptane. However, the preparation of a diluent with an aniline point of 60.0°C. involves a certain amount of work, and the value of 60.0°C. has no significance except for comparison. For that reason a mixed aniline point using n-heptane has been employed in these laboratories. This material has the advantages of being uniform in composition, of being available commercially, and of giving a convenient mixed aniline point for most materials. The mixed aniline points (using n-heptane) of a number of compounds are given in Table 9. It will be noted that toluene gives a lower mixed aniline point than benzene. This agrees with data previously published.[14]

There appears to be no simple relationship between mixed aniline point and true aniline point. In the preceding section it was suggested that the aniline point divided by the boiling point might be additive on a weight basis. Table 10 shows the calculation of mixed aniline points from the aniline points of the components by 3 different methods but indicates that none of them gives the correct answer for all mixtures. It gives the volumetric average of the aniline point and the mixed aniline points calculated from both weight and volume averages of the ratios of aniline point to boiling point (in °K.) Of the 3 methods the volumetric average of aniline point divided by boiling point seems to give the best results in most instances; however, the errors were large when materials whose boiling points varied widely were included in the mixture. Mixtures of materials whose aniline points do not differ significantly may be calculated satisfactorily by the simplest method, that is, volumetric average of the aniline points of the components. Table 11 gives the aniline point of benzene calculated by each of the three methods. As would be expected, no one method gave consistent results.

It is assumed that aniline points below −6 °C. (melting point of aniline) are theoretical and that any attempt to verify them experimentally would be open to question because of the extra forces introduced at the melting point. Gillam[13] states that aniline points can be determined down to −20° to −30°C., but it is questionable whether such values would be comparable with data from the ordinary temperature range. The data available for the lower-molecular-weight members of the aromatic series indicate that the results might be erratic. If theoretical values that agree with blending results can be obtained by calculation, they will be useful.

Aniline points are used chiefly: (1) in analyzing low-boiling hydrocarbon mixtures, (2) in analyzing high-boiling oils qualitatively to determine the predominant hydrocarbon types, and (3) for evaluating ignition properties of certain fuels. They also are used to a limited extent in evaluating paint thinners[12] and for predicting the swelling properties of synthetic rubbers upon exposure to different types of oils.[15]

The estimation of aromatics in a hydrocarbon mixture by the use of aniline points or critical solution temperatures has been suggested by a number of investigators.[16] The aniline point or critical solution temperature is determined before and after the aromatics have been removed with an appropriate reagent such as sulfuric acid. The difference between the two values is multiplied by a factor to give volume percentage of aromatics. This factor has been shown to vary for different boiling ranges and different concentrations of aromatics.

When unsaturates are components of a hydrocarbon mixture their separate removal often is not satisfactory, so they usually are removed with the aromatics. The depression of the aniline point by the unsaturates may be calculated from the bromine number of the original gasoline[17] and subtracted to give the aniline-point depression due to the aromatics. Another method[18] is to measure the total amount of unsaturates and aromatics removed by sulfuric acid and the consequent lowering of the aniline point and to set up two equations by means of a factor relating olefin content to the aniline-point depression caused by the olefins and a similar constant for aromatics; these can be solved simultaneously for content of unsaturates and aromatics.

Methods for estimating percentages of naphthenes and paraffins from the aniline point of the gasoline after removal of unsaturates and aromatics have been described.[19] The calculation usually is made by establishing a base value for paraffins and assuming that lowering of the value is produced by naphthenes. Multiplication of this lowering by the aniline factor gives the naphthene content of the aromatic-free and unsaturate-free gasoline.

Factors given for these conversions are shown in Table 12. It will be noted that in general these factors rise for increasing molecular weights. Because the aniline point of mixtures is not a straight-line function with composition, the values of the factors vary with the concentrations of the classes involved. Base values for aniline points of paraffins are given in Table 13.

The aniline factors increase with boiling point to make the analysis comparable with the older sulfuric-acid method. In the sulfuric-acid method all compounds containing an aromatic ring are extracted, and the reduction in volume is measured. Aniline points, however, reflect the composite character of such compounds as n-nonylbenzene, which besides containing an aromatic nucleus also contains a paraffin chain of considerable proportions. To approximate results of the sulfuric-acid method a much higher aniline factor must be used than would be used for a benzene solution.

Although the aniline-point method gives good results for narrow-boiling fractions that contain only one aromatic compound, selection of the proper aniline factor becomes more difficult for wider fractions, and the results are less

TABLE 12—Aniline Factors for Various Classes of Hydrocarbons

Class	Boiling range °C.	Aniline factor*
Unsaturates	Unspecified	2.5
	65-95	2.3
	95-122	2.4
	122-150	2.8
	150-200	2.7
		2.5 value for aromatics
Aromatics	Unspecified	1.19-1.00
	65-95	1.15
	95-122	1.20
	122-150	1.25
	150-200	1.50
	Kerosine	1.16-1.24
Naphthenes	Unspecified	3.33
	230-365	2.50
	60-95	3.00
	95-122	4.00
	122-150	4.50
	150-200	5.00
	Up to 150	3.23

*Aniline factor is a factor that multiplied by the lowering of the aniline point due to a certain class of hydrocarbons gives the percentage of that hydrocarbon class present.

TABLE 13

Base Values for Aniline Point of Paraffins in Various Boiling Ranges

Boiling Range °C.	Aniline Point °C.
Entire range	70.0
Up to 150	71.8
60-95	71
95-122	71
122-150	73
150-200	76
230-280	86.7
280-300	91.8
300-315	95.1
315-335	97.9
335-365	100.8

accurate. The statement holds for the unsaturates. As the carbon chain lengthens in the olefin series, the double bond becomes less important; the aniline point reflects this fact. Thus, the volume percentage of unsaturates gives no information regarding the degree of unsaturation and so requires an assumption of such degree (usually one double bond per molecule) to permit its comparison with bromine number or its calculation from aniline point data.

Vlugter, Waterman, and van Westen[20] have developed the "ring analysis" method, which is based on the determination of molecular weight, specific refraction, and aniline point. This method gives results in percent aromatic rings, percent naphthenic rings, and percent paraffin chains. It is more suitable for high-boiling oils and is not adapted to the analysis of oils containing unsaturates.

Aniline points have been used rather extensively in studying the composition of lubricating distillates.[21] In general, the methods consist in locating the data for a particular sample of oil on a graph similar to Fig. 1. Thus, for example, the first of a series of sulfur-dioxide-extracted fractions might be placed at

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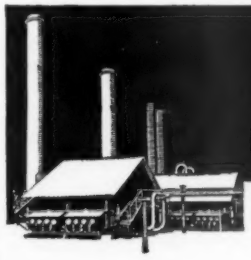

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TABLE 14
Comparison of Diesel Index with Cetane Number for Some Pure Hydrocarbons

Compound	Aniline point °C.	Aniline point °F.	A.P.I. gravity*	Diesel index	Cetane number
n-Heptane	69.7	157.5	74.1	117	57
Cetane	95	203	50.4	102	100
Cetene	69.4	156.9	48.7	76	88
Dicyclohexyl	47.6	117.7	28.4	33	53
n-Nonylbenzene	—11	12.2	32.0	4	50
n-Dodecylbenzene	14	57.2	32.4	19	68
n-Tetradecylbenzene	27.1	80.8	33.8	27	72

*Calculated from values by Doss, M. P., Physical Constants of the Principal Hydrocarbons: New York, 3d ed., 1942.

the bottom of the chart, indicating high aromatic content. As extraction proceeded fractions might be obtained whose properties would place them nearer the center of the chart. This position would indicate that the extracted portions were becoming more naphthenic. Oils whose properties would be plotted near the top of the chart would be more paraffinic.

Watson, Nelson, and Murphy[22] have correlated critical solution temperatures in aniline with a "characterization factor". This factor, which is defined as the ratio of the cube root of the average boiling point in degrees Rankine to the specific gravity at 60°F., ranges in value from 12.5 to 13.0 for purely paraffinic stocks to 10 or less for aromatic materials.

Perhaps the most useful relationship of the physical properties of hydrocarbons would be a simple one between ignition quality of fuels (octane number or cetane number) and one of the other more easily determinable properties. As none has been found, it has been necessary to use more complicated relationships or to determine the ignition quality by engine tests.

Attempts have been made to correlate aniline points with antiknock tests for gasoline,[23] but they have met with slight success owing in part to the fact that aniline-point values generally increase with branching of the carbon-carbon chain and decrease with a higher C-H ratio in hydrocarbons of a fixed number of carbon atoms. Octane numbers, on the other hand, increase with both of these changes. Francis[4] suggests a relationship between octane number, boiling point, and aniline point for paraffins. He found that the sum of the boiling point and aniline point gave a straight line for each set of isomers.

Aniline points have been used with more success for evaluating ignition properties of diesel fuels. The diesel index (aniline point in degrees Fahrenheit times A.P.I. gravity at 60° F. divided by 100) was proposed[24] for the evaluation of diesel fuels and was included for several years as an alternate method for measuring ignition quality in diesel fuel-oil classification by the American Society for Testing Materials.[25]

When the society adopted the engine method of test the diesel index determination was dropped. However, many laboratories that have no facilities for making an engine test continue to use the diesel index. Some correlation between the diesel index and the cetane number as determined by the engine is revealed for pure compounds in Table 14. The limited data indicate, however, that other factors must be considered and that while the diesel index may be of practical value it must be used with care.

* * *

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Mercaptan Removal by Unisol Treating Effects Savings in Small Refinery

*By F. C. Moriarty**

FOR more than 18 months a Unisol treating unit has been operating in the refinery of the Big West Oil Co. at Kevin, Mont. The Unisol process, licensed by Universal Oil Products Co., removes mercaptans by extraction with a concentrated solution of caustic soda containing methanol. It is used to treat the gasoline produced by the Dubbs cracking unit in the refinery.

Before the process was installed the gasoline had been treated by doctor sweetening. This was expensive and reduced the octane number from one to two points, as well as causing a rather large loss of gasoline. With the Unisol unit the mercaptan content of the gasoline is being reduced from 0.06-0.11% to an average of 0.007% as it leaves the treating unit, and it usually becomes doctor sweet, or nearly so, after a few days in storage.

*Universal Oil Products Co., Chicago.

As soon as the Unisol operation was well under way, Big West shut down the doctor sweetening unit. In contrast to the loss of one or two octane numbers caused by doctor sweetening, the new treating increased the unleaded octane number by one-half point. The reduction in mercaptan content is accompanied by a corresponding reduction in total sulfur and a substantial increase in tetraethyl lead susceptibility. Formerly, Ethyl grade gasoline (then 80 octane) could not be produced in the Big West plant. After Unisol treating, the addition of 3 cc of tetraethyl lead per gallon to the cracked gasoline makes an 80 plus octane product.

Of greater importance is the fact that the increase in tetraethyl lead susceptibility makes it possible to blend all the straight-run gasoline with the cracked product and produce housebrand gasoline. When operating the doctor sweetening unit, it was necessary to add 1.1 cc of tetraethyl lead to the cracked gasoline to reach 74 octane number. If any substantial quantity of straight-run was blended with the cracked gasoline it could not be brought to 74 octane. By contrast, a typical sample of Unisol-treated cracked gasoline, when blended with 10% straight-run and 0.65 cc of tetraethyl lead, made 75 octane number.

The overall cracking and treating loss of gasoline for nine months before the Unisol unit went into operation had been 9%. The loss the following nine months was 5.9%, or a reduction of 3.1%. Some of this reduction in loss may have resulted from minor changes in the cracking unit but it is believed that at least 50% of the reduction can be credited to the Unisol operation. The original loss was high because of deficiencies in the doctor sweetening operation. Such deficiencies are aggravated when a gasoline high in mercaptan content is processed. Analysis of the mercaptans separated from the gasoline shows only a trace of dissolved hydrocarbons, thus proving that the loss in treating is insignificant.

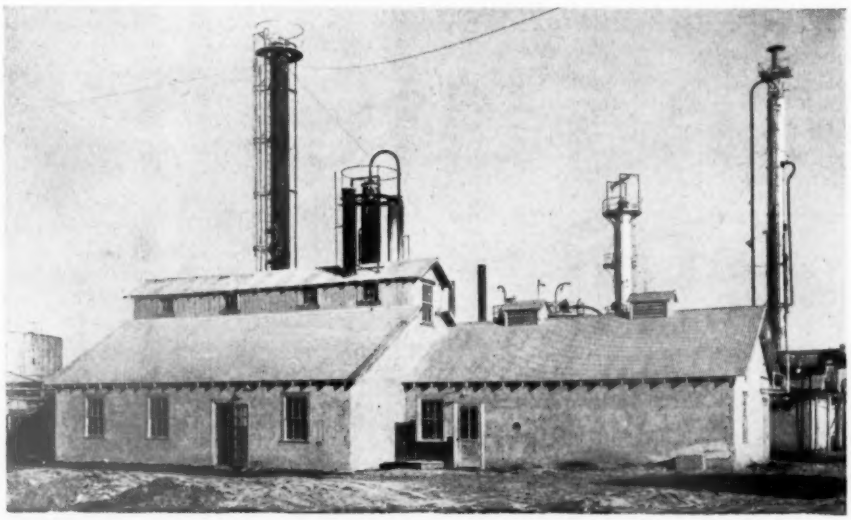
The Big West unit processes approximately 550 bbl. of gasoline a day. It is to be expected that losses of reagent in a plant of that capacity would be greater proportionately than in a larger unit, as the smaller unit has the same number of packing glands, sample valves, etc. Nevertheless, the Big West unit consumes less than two gal. per day of methanol, and the total cost of reagents is well below 0.5c per bbl. treated. Labor costs too are low, as only part of the time of one operator per shift is necessary.

There have been no process difficulties. However, corrosion in the bottom of the caustic recovery section, which is made of carbon steel, is so severe that it was necessary to replace a 24 in. x 10 ft. section after eight months' service, and it has been necessary to repair it several times in addition. This section is flanged to make replacement easy, and thus has not been a serious handicap to operation of the unit. Nickel-clad steel will be used when it is again available to eliminate the corrosion problem.

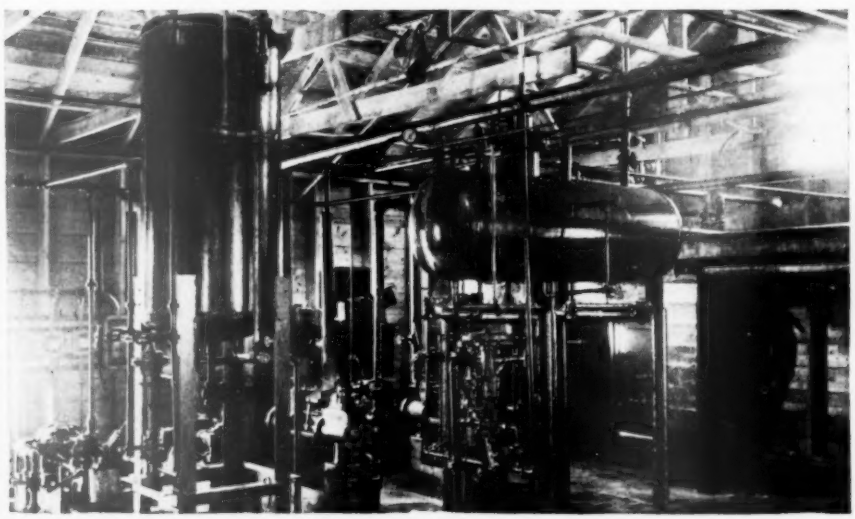
No difficulties have been encountered in operating the Unisol process, even under the subzero weather conditions encountered in Montana.

The inhibitor susceptibility of the Unisol-treated product is excellent. The addition of 0.007% of U.O.P. inhibitor No. 4 to the finished gasoline increases the induction period by approximately 250 minutes, and the copper dish gum (Atlantic method) of the inhibited gasoline has been consistently below 10 mg.

The saving of tetraethyl lead in gasoline, together with the appreciated value of the product and decrease in gasoline loss, indicates a remarkably short retirement period for the initial investment in the Unisol treating unit.



Building for housing Unisol unit at Big West refinery, with fractionating towers of the refinery in background



Methanol column receiver and mercaptan separator in Unisol treating unit at Big West Oil Co. refinery at Kevin, Mont.

The Combustion Gas Turbine

Wartime Developments in Metallurgy and Aerodynamics Point Way for Increased Applications of This Prime Mover

Increasing attention is being given to the combustion gas turbine as a prime mover. Potentially it promises greater efficiency at very high temperatures than most engines and prime movers used today.

Principal commercial applications in this country have been in connection with Houdry catalytic cracking units. In this use, air required for regeneration of the catalyst is drawn from the atmosphere, compressed, and then sent to the catalyst case, where it burns out the carbonaceous deposits. Hot fumes leaving the case are then run into the gas turbine, and upon expansion produce power to drive the compressor which feeds the original air into the catalyst case. In some instances the gas turbine not only operates the air compressor but may also be coupled to a generator for production of electric power. Similar refinery applications using flue gases may be developed as gas turbines increase in efficiency.

The petroleum refiner, as a supplier of fuel, also watches with interest the development of other industrial applications of the gas turbine. These may to some extent depend upon development of equipment which can use low grade oil, instead of the high grade oil now necessary.

The following article, by two engineers connected with Westinghouse Electric and Mfg. Co., explains the various types of gas turbines and how they operate, and compares the efficiency of the gas turbine with that of the steam turbine.

By F. K. Fischer and C. A. Meyer***

THE fundamental directness of the gas turbine power cycle, in which all the hot gases of combustion are led straight to the turbine, has intrigued engineers for years. Versatile Leonardo da Vinci devised a crude version. In 1791, John Barber, an Englishman, took out the first patent on a turbine operated by gases. Since that time there has been an almost continuous stream of developments.

Progress toward a practical gas turbine power unit has been delayed because the thermal efficiency required to make it competitive with the newly developed steam cycle required: (1) operation above 1000°F.; (2) a highly efficient compressor; and (3) a highly efficient turbine.

Two seemingly unrelated industries have recently made important contributions to help solve these problems. Metallurgists, in developing materials for superchargers have produced alloys that are expected to withstand at least 1200°F. continuous service at the low operating pressures encountered in gas turbine work. Aviation and wind tunnel research on airplane propellers and wings have contributed fundamental aerodynamic data on which high efficiency compressor designs are based. Research in these two industries plus the accumulated steam experience of many years have made possible the necessary high-efficiency turbine and compressor elements, and solved many mechanical problems involved in gas turbines.

The open cycle combustion gas turbine eliminates a big and expensive step in providing power to drive generators or machinery. In its power cycle, all the hot gases of combustion go straight to the turbine, thus eliminating the steam boiler. By contrast, in the highly developed steam cycle, fuel energy must be converted to steam, at a comparatively low temperature, before expending its energy in the turbine. In the combustion gas turbine system of power generation there are two basic cycles—the open cycle for moderate capacities and the closed-cycle for very large units.

The gas turbine employs the simplest power cycle known, consisting of three major elements: compressor, combustor and gas turbine. These elements are shown as longitudinal sections in true relative size in Fig. 1. The turbine resembles the straight reaction, non-condensing steam turbine. Its blades look more like air foil sections than reaction steam turbine blades, due to the small pressure drop and large gas volume involved. The axial-flow compressor also resembles a straight reaction turbine, with the gas to be compressed passing axially through the compressor. The action of the blades in the axial flow compressor is the reverse of the action of expansion in a reaction turbine. This physically-small compressor handles the large volume of gas efficiently. The combustor is the burner in which chemical energy of fuel oil is converted into heat energy, by burning the fuel with sufficient excess air to obtain the desired temperature. The hot product of combustion from the combustor is the gas, which, expanding to a lower pressure and temperature in the gas turbine, converts some of its heat energy into mechanical energy at the turbine shaft. The combustor is relatively small since its rate of heat release is many times that of the conventional steam boiler, which,

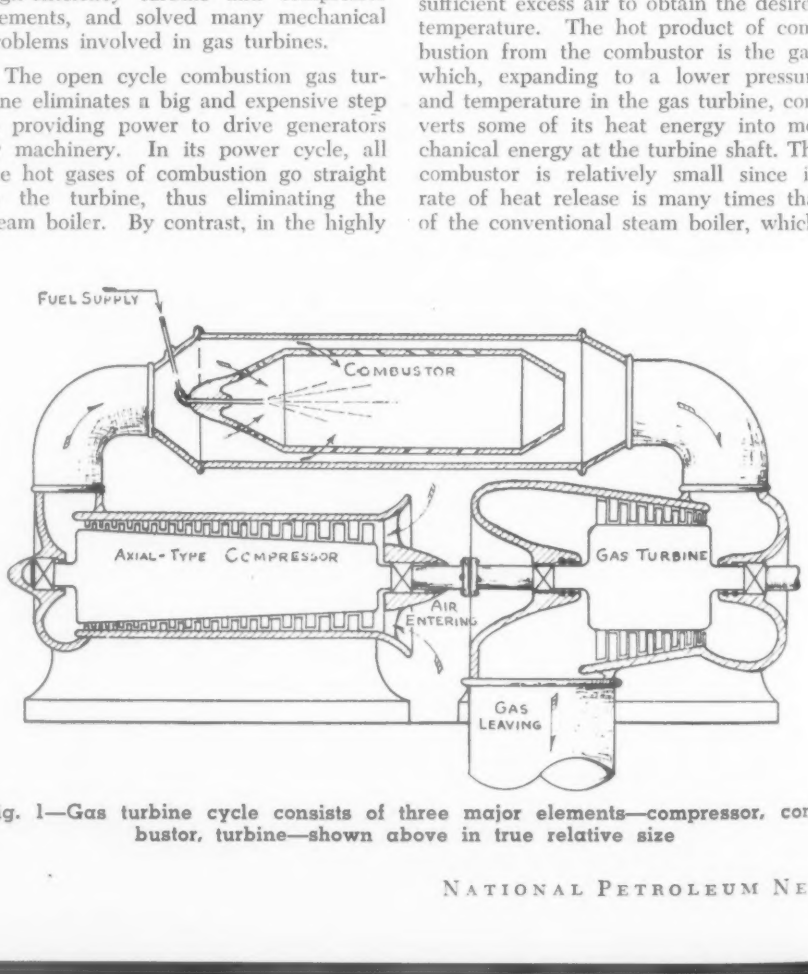


Fig. 1—Gas turbine cycle consists of three major elements—compressor, combustor, turbine—shown above in true relative size

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**Development Engineer, Westinghouse Electric and Mfg. Co., S. Philadelphia, Penna.

in addition to burning fuel, must transfer heat through tube walls to generate steam.

How Cycle Works

The combustion gas turbine cycle in its basic form comprises three major elements previously mentioned: compressor, combustor and gas turbine; plus a generator or shaft for transmitting the useful power output, and a means of starting. This simple arrangement is called the open cycle system. To start a combustion gas turbine some external means, such as a motor, is required. This is necessary as air for combustion is supplied to the combustor by the compressor. When the unit is in operation energy to drive the compressor comes from the expansion of the products of combustion in the gas turbine.

In the simple cycle operating at 1200°F., the products of combustion (gas) contain some 600 per cent excess air. This gas is expanded in the turbine and exhausted to the atmosphere. No intermediate fluid is used as in the steam cycle, where fuel is burned and releases chemical energy as hot products of combustion which pass through a steam boiler to generate steam for the steam turbine. The steam generator, or boiler, is the biggest single element in the steam power plant. In the gas cycle a compressor and combustor replace the boiler, resulting in a much smaller and more compact power plant. Because the simple open combustion gas cycle does not require cooling water, no steam condenser such as used in the condensing steam cycle is needed and plants may be located without regard to a suitable source of cooling water.

Although the first patent was taken out over 150 years ago, early inventors were unsuccessful in getting units efficient enough to drive their own compressor. The cycle was perfectly sound, but these early inventors lacked materials to withstand the necessary high temperature, plus turbines and compressors of suitable efficiency.

High-Temperature Metals Developed

Today the story is changing. Materials capable of operating at high temperatures are available. The maximum temperature employed is largely a question of the useful life. For a life of relatively few hours, such as might be satisfactory for some military needs, temperatures of the order of 2000°F. are allowable. Heavy duty or long life applications are limited to much lower temperatures. The tremendous advances in metallurgy for the war effort will undoubtedly produce materials capable of operation at temperatures which we would not have attained for many years under a normal peace time development.

The combustion gas turbine requires tremendous volumes of gas. The axial flow compressor, small in physical size, efficiently handles the large volumes required. Until recently the axial flow compressor was largely an unknown quantity. Today, the advancement in knowledge of proper blade shapes and research in the development of efficient air foil sections have given the designer the necessary tools to design and build highly efficient axial flow compressors.

In the gas turbine cycle, the useful power output depends upon obtaining relatively high turbine and compressor efficiency. The useful net output is the difference of two fairly large quantities: the total turbine output and the work consumed by the compressor in compressing the air. With the system shown in Fig. 2 operating at a top temperature of 1200°F., the turbine develops 3.95 units for each useful unit of power output, of which 2.95 units are needed to drive the compressor. A reduction of 1% in the efficiency of each of these elements reduces the useful output by 7%. The useful output decreases sharply as the top temperature is lowered.

Engineers have been experimenting with this combustion gas cycle for many years. In Europe, because of economic conditions, engineers attempted to develop it as soon as materials and compressors even remotely offered a possibility of building successful units. In this country, much of the recent development is of necessity not published because of Government security reasons. However, in the literature there has been a considerable description of prewar applications in Europe. These plants are inferior in efficiency to what can be built today, but they are apparently giving satisfactory results. Interesting applications include a turbine locomotive, electric generating set, compressor drive for Velox boiler, refinery drives and airplane propulsion. Brief details are given in the bibliography.

Regenerating, Intercooling, Reheating

Efficiency of the simple open gas cycle is low unless extremely high temperatures are used. However, there are three practical ways of greatly improving the gas cycle efficiency: regenerating, intercooling and reheating. The regenerating gas cycle is a cycle in which a heat exchanger (regenerator) transfers some of the heat from the relatively hot exhaust gases leaving the turbine to the air before it enters the combustor, as shown in Fig. 3. Heating the air by exhaust gases reduces fuel consumption and improves the cycle efficiency. The amount of heat obtained from the exhaust gas depends on the size of the heat exchanger. This is an economic problem in which gain in efficiency is balanced against cost of heat exchanger surface. Calculations indicate that the economic size of the heat exchanger will limit the regenerating cycle, at 1200°F. inlet temperature, to approximately 75%

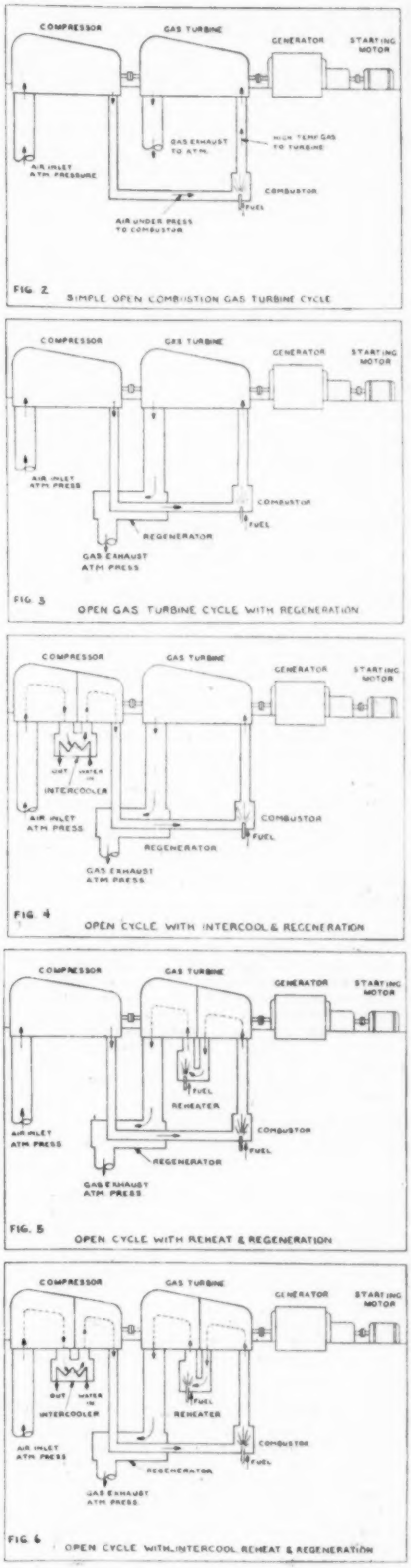

Fig. 2-6—Top drawing shows simple open cycle gas turbine. Lower drawings indicate how Regenerator, Intercooler and Reheater units are added. Bottom drawing shows all three elements added to increase efficiency of open cycle gas turbine (at 1200° F) from 20.2% to 32.2%

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recovery of the heat available from the turbine exhaust gases. This economic size will be about 0.30 cu. ft. of heat exchanger volume per kw of capacity.

Efficiency is further improved when intercooling is added to regeneration as shown in Fig. 4. As the name implies, intercooling removes the heat of compression from the air passing through the compressor. Water circulating through the intercooler cools the air, and is a necessary part of the cycle. By intercooling, the compressor work is reduced because the colder air has smaller volume. Other conditions remaining the same, one stage of intercooling will reduce the compressor work by some 15%. This increases the portion of the turbine capacity available as useful output and improves the cycle efficiency. A large number of intercoolers is ideal but probably only a few stages will be practical.

The third method of improving efficiency, reheating, consists of adding heat to the gas as it passes through the turbine as shown in Fig. 5. The gas turbine reheat cycle is the same principle as the reheat cycle used in many steam plants. In practice it will bear little resemblance. Reheating in the gas turbine will consist of burning fuel directly in the gas (approx. 85% air) passing through the turbine. The quantity of large steam piping and considerable heat transfer surface in the heat exchanger of the steam reheat cycle will be replaced by a reheating combustor which may possibly be placed inside the gas turbine casing proper. Here again, the practical number of reheats is limited.

Reheating and intercooling increase the amount of useful energy per pound of working gas passing through the system, thus reducing the number of pounds of working medium circulated. Therefore, the size of piping and blade path in the compressor and turbine are reduced. In combination with a regenerator, the terminal difference across the heat exchanger is greater for a given size exchanger, or a smaller heat exchanger transfers the original amount of heat. In partial load operation they increase the partial load efficiency by a considerable amount.

Cycle Combinations Compared

The combination of regenerating, reheating and intercooling is shown in Fig. 6. Different cycle arrangements are compared in Table I on the basis of the power requirements of each major element, with the capacity of the generator as unity. The efficiency of each cycle arrangement at 1200°F. is given, the temperature in degrees Fahrenheit, and the absolute pressure at different points in each cycle.

The thermal efficiency of the open cycle gas turbine for various combinations of regenerating, reheating and intercooling is shown in Fig. 7. This gives the relative value of these modifications and a general idea of possible applications of this cycle. The temperature range of 1000°F. to 1500°F. was chosen because applications at temperatures much below 1000° will undoubtedly be impractical. Early applications for heavy duty long-life apparatus will probably not exceed temperatures of 1200°F., with 1500°F. and higher limits awaiting future developments in metallurgy.

The temperature of the inlet air to the compressor has a marked effect on the cycle efficiency. In contrast to steam plants the colder this inlet air the higher the cycle efficiency and capacity. In the simple open cycle, changing the inlet air temperature 10°F. changes the cycle efficiency 0.74 points or approximately 3% per 10°F. change. The effect

Table 1—Comparison of Different Open Cycle Arrangements

Item	Simple Cycle	Cycle with Regeneration	Intercool and Regenerate	Reheat and Regenerate	Intercool, Reheat and Regenerate
Figure No.	2	3	4	5	6
Input in Fuel	4.95	3.75	3.43	3.55	3.11
Turbine Rating	3.95	2.95	2.80	2.88	2.55
Compressor Power	2.95	1.95	1.80	1.88	1.55
Useful Output	1.00	1.00	1.00	1.00	1.00
% Eff. at 1200°F.	20.2	26.6	29.2	28.1	32.2
Gas Temp. in °F. at					
Turbine Inlet	1200	1200	1200	1200	1200
Leaving Reheater	...	...	...	1200	1200
Turbine Exhaust	635	790	695	920	865
Leaving Regenerator	...	455	350	560	520
Air Temp. in °F. at					
Compressor Inlet	70	70	70	70	70
Leaving Intercooler	...	...	70	...	...
Leaving Compressor	490	340	230	440	405
Entering Combustor	490	680	575	800	750
Press. lbs/sq. in. abs. at					
Compressor Inlet	14.7	14.7	14.7	14.7	14.7
Compressor Discharge	88.2	51.5	73.5	73.5	102.9
Turbine Inlet	88.2	50.2	71.7	71.7	100.4
Turbine Exhaust	14.7	15.1	15.1	15.1	15.1

on capacity is approximately 4% per 10°F. change. The effect on cycle thermal efficiency of inlet air temperature, on the different cycle arrangements with a top temperature of 1200°F., is plotted in Fig. 8.

Steam, Gas Cycles Compared

Because steam is the most widely used medium for transferring heat into mechanical energy, comparison of the steam cycle with the gas cycle may help in judging the gas cycle and its possibilities. In judging the efficiency of power cycles, a 100% thermal efficiency is not obtainable as the temperature of the cold body is far above absolute zero. The Carnot Cycle is the theoretically perfect cycle, and no cycle operating between the same hot and cold body temperatures can have a better thermal efficiency. The best any cycle can hope to do, when operating under the same conditions, is to attain the Carnot Cycle efficiency. The gas turbine cycle can theoretically give the same efficiency as the Carnot Cycle. This is only theoretically possible because it requires 100% efficiency of the gas turbine and compressor, an infinite number of stages of intercooling and reheating, and a regenerator infinite in size.

The steam cycle theoretically offers the Carnot Cycle efficiency only up to the critical pressure (705.4°F.; 3206 psi Abs.). Above this temperature, the gap between the steam cycle and the ideal cycle gradually widens as the temperature is increased. From a purely theoretical standpoint the combustion gas turbine cycle holds forth greater promise of efficiency than the steam cycle.

Of more value are the thermal efficiencies obtainable in practical applications. Fig. 9 compares the best efficiencies obtained in large central station power plants (projected to 2000°F.) with the expected practical limit in efficiency of the large capacity closed cycle combustion gas turbine power plants. Above 1000°F. gas cycle efficiency increases approximately three times as fast as steam cycle efficiency for a given top temperature increase.

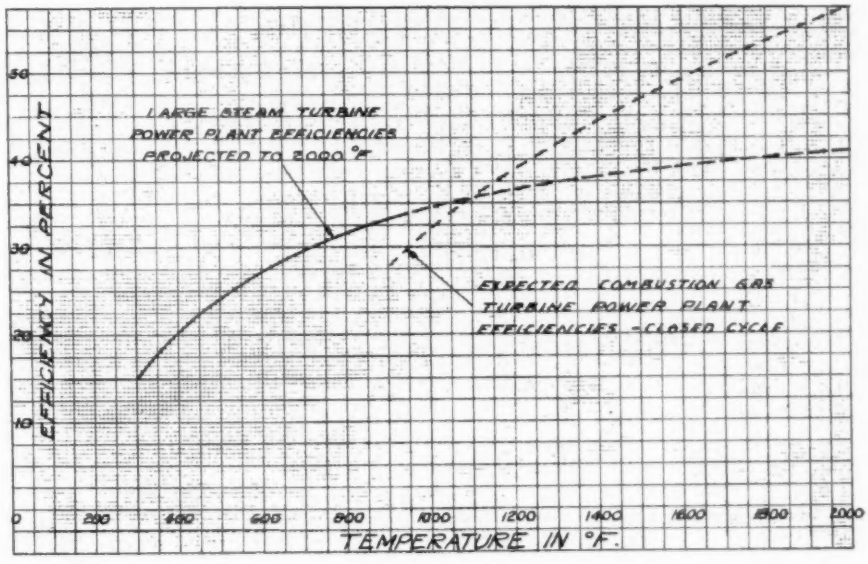
LARGE STEAM TURBINE POWER PLANT EFFICIENCIES PROJECTED TO 2000 °F
EXPECTED COMBUSTION GAS TURBINE POWER PLANT EFFICIENCIES - CLOSED CYCLE
EFFICIENCY IN PERCENT
TEMPERATURE IN °F.

Fig. 9—Comparison of efficiencies of best practical steam power plants and combustion gas turbine plants. Above 1000° F gas cycle efficiency increases about three times as fast as steam cycle efficiency

This curve compares the best modern large central station steam power plants with the best practical efficiencies expected of the combustion gas turbine power plants. It is expected that the gas turbine cycle efficiency will not be greatly affected by unit size, and this combustion gas cycle curve can also be interpreted as applying to open cycle gas turbine power plants of relatively small capacity. Economic steam plants for capacities around 5000 kw seldom exceed 25% overall thermal efficiency. This would indicate a considerable efficiency advantage, in small units, in favor of the gas cycle, provided economics permit designing it for anywhere near its maximum possible efficiency.

The ratio of exhaust to inlet volume

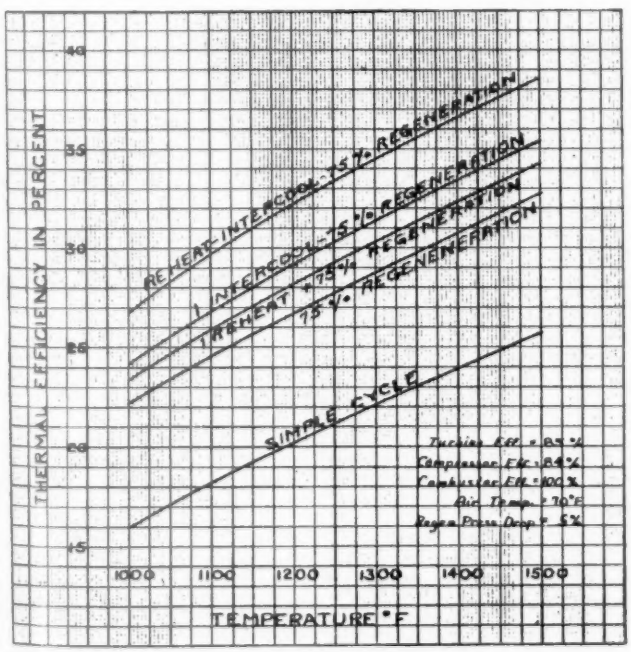

Fig. 7—Thermal efficiency of open cycle gas turbine with various combinations of regenerating, reheating and intercooling

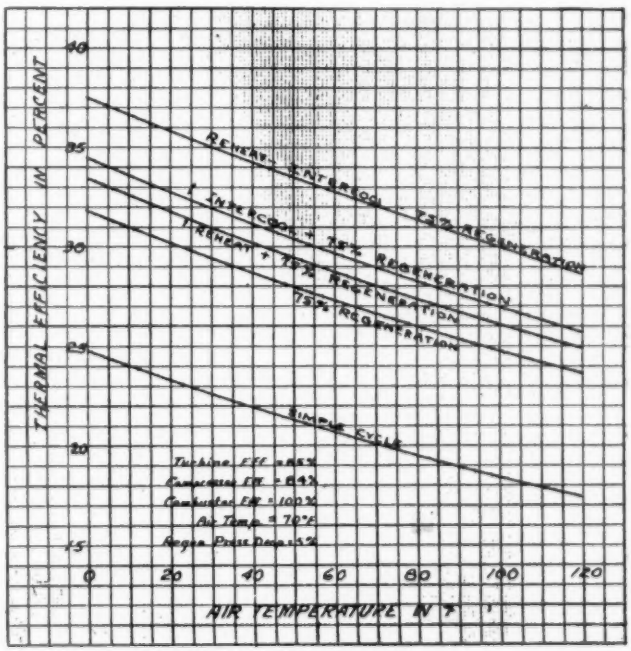

Fig. 8—Effect of air temperature on thermal efficiency of open cycle gas turbine with inlet gas temperature of 1200° F

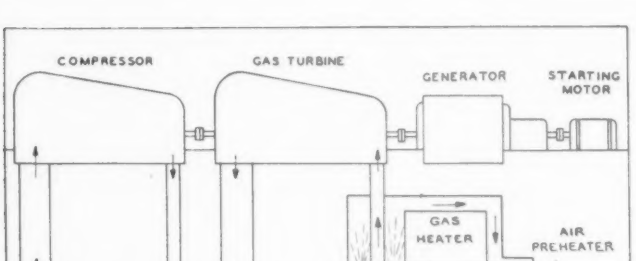

Fig. 10—Externally fired closed cycle gas turbine used by Escher Wyss, in which products of combustion do not pass through gas turbine

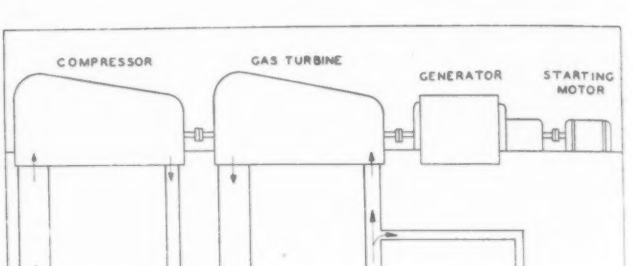

Fig. 11—Internally fired closed cycle gas turbine being developed by Westinghouse. Note separate turbine and compressor used to pump up main system

is small for the gas turbine. This makes a balanced blade path unlike that of the steam turbine, which in this case must handle an exhaust volume 250 times as great as the inlet volume. The large blade dimensions limits the maximum net output rating of the open cycle, single flow, combustion gas turbine to approximately 7500 kw. However, the injection of liquids presents a theoretical possibility considerably extending this limit.

Closed Cycle For Large Units

The closed cycle offers a method of increasing the maximum capacity of the open cycle. The volume of the working gas is inversely proportional to the absolute pressure. If the pressure is multiplied by 10, the size is divided by 10. In the closed cycle, the circulating working gas is at a relatively high pressure and reduces the physical size of compressor and turbine. To reduce the temperature of the gases before they enter the compressor, cooling water is required in the closed cycle. The heat exchanger in which the gas is cooled before it enters the compressor is called a gas precooler. The amount of heat given up to the cooling water is equivalent to that removed in the condenser of a steam unit of equal capacity. The quantity of cooling water required will be less, as a higher water temperature rise is permissible.

The closed cycle in Fig. 10 is the one used by Escher Wyss.* This is an externally fired cycle in which the products of combustion do not pass through the gas turbine and compressor. The working gas (air, hydrogen or other medium) operates at a relatively high pressure in a closed, recirculating circuit. In the gas heater, the heat from the products of combustion is transferred to the working gas which then expands in the turbine to a lower pressure. The gas heater in this cycle corresponds to the steam boiler in the steam cycle. For a practical efficiency, it will be larger than the modern steam boiler because gases are on both sides of the gas heater. This cycle is very similar to the steam cycle, except that the working fluid does not undergo a change of state.

In the closed cycle, the compressor inlet pressure will be maintained at approximately 150 psi with a discharge pressure of some 600 psi. This high pressure greatly reduces the size of turbine and compressor and should permit maximum ratings to be built approaching those in the steam cycle. Some gas other than air will probably be used as the working medium in the externally fired closed cycle. Hydrogen, for example, has properties which make it far superior to air for this application. The density of hydrogen is 1/14 that of air, the specific heat is 14 times that of air, and the thermal conductivity is 6.8 times that of air.

A closed cycle system under development by Westinghouse, is shown in Fig. 11. In this closed cycle a separate gas turbine and compressor are used to pump up the cycle on which the main gas turbine and compressor operate. High pressure of around 600 psi may be used with a compressor inlet pressure of around 150 psi. The main gas turbine and compressor would be small as they operate at high pressure. This cycle is internally fired, the products of combustion passing through the gas turbines and main compressor. Enough make up air is continually supplied to maintain pressure and support combustion. It is supplied by a compressor which is driven by a second gas turbine. This cycle avoids the large gas heater required by the Escher Wyss cycle, but requires an extra gas turbine and compressor to pump-up the system. Solid matter from the fuel must be removed.

In the closed cycles shown in Figs. 10 and 11, reheating and intercooling are not illustrated. However, they offer the same advantage in the closed cycle that they offer in the open cycle. The biggest single additional problem in the closed cycle is a method of building practical heat exchangers. The problem is further complicated by the fact that the gases will carry foreign matter from combustion which may both corrode and erode the exchanger and reduce the heat transfer rate by depositing foreign material on the transfer surface.

Gas Turbine Control

Combustion gas turbine control can be simple and reliable, consisting only of control of the gas temperature by controlling the rate of fuel supply. Governing valves, such as used in steam turbine control, are not needed. Efficient partial load performance can be obtained by using two turbines: one variable speed turbine driving a compressor, plus a constant speed turbine driving a generator. The use of regenerators, reheaters, and intercoolers in addition to improving the full load economy have an even greater effect in improving the partial load economy. In the closed cycle, by reducing the gas pressure as the load is reduced, practically full load efficiency can be maintained at partial loads.

Possible Applications

Possible applications of the gas turbine are many. Ranging from a simple open cycle for small capacities to a closed cycle for very large ratings it offers wide possibilities. For example:

Locomotives. The simple open gas cycle requires no water. It has low weight and small space requirements combined with simplicity. With an efficiency of 20% at 1200°F. and expected low maintenance of turbine drives, it should prove a good power plant for a locomotive. The inability of the gas

*"An Aerodynamic Heat", Power Plant Escher Wyss News, 1939, No. 1, 2.

turbine to operate in reverse makes either electric drive or the development of a satisfactory reversing gear necessary for this application.

Airplanes. For relatively small power outputs, such as required by the airplane industry, the gas turbine operating at high speed and high temperature to obtain maximum rating per unit weight of material, has real possibilities.

Ship Drives. The combustion gas cycle offers efficiencies equal to the best modern marine steam power plants, which have overall efficiencies of approximately 25%. Weight and space requirements of equipment are a real factor in this application. The gas cycle eliminates the steam generator and steam condenser. The advantage in weight and space undoubtedly will favor the gas cycle, despite the gas compressor, the regenerator heat exchanger, and the large gas turbine. The requirements of astern operation in marine service handicaps the gas turbine, except as an electric drive.

Power. General application of the combustion gas cycle in the power generation field will probably not take place until problems in connection with the use of coal as a fuel are solved. The successful development of the closed cycle is necessary if units of very large capacity are to be built. The maximum capacity for which units can be built in the open cycle will include the majority of industrial applications. There are many special applications in the power generation field in which the open gas cycle will possibly find early application. Examples are: emergency standby service, and low first cost units on the ends of transmission lines. Here a simple open gas cycle offers many advantages, such as no water required, low first cost, simplicity, small space requirements, and virtually automatic station with few attendants.

Processing. In the industrial field where both power and process steam are required the gas turbine has possibilities. It fits well in those applications where the steam required is relatively small in relation to the power load. This is different from the extraction steam turbine where large quantities of process steam per kw are necessary to attain a comparably efficient cycle. Here again, the use of coal as a fuel is necessary for a wide general application.

Problems Ahead

In drawing conclusions, it should be remembered that the gas cycle has had practical application only in very special cases. The full possibilities of any cycle can be evaluated only from successful proof of its economy, first cost, maintenance cost and reliability. The addition of elements which improve the fuel economy, and arrangements of the cycle for large capacities, are obtained at a sacrifice in simplicity and at a price. The development of the best system is expected to be costly in time and money.

Metallurgy plays an important part in the gas cycle as the efficiency increases rapidly with increase in top temperature. To obtain materials suitable for operation at higher temperatures the metallurgists are looking at materials similar to the non-forgable and non-machinable tool steels. The method of forming these alloys to shape, such as precision casting to size, may revolutionize accepted methods of manufacture. To apply such materials their additional first cost and manufacturing cost must be justified. Any application of such materials must be preceded by careful tests. For heavy duty apparatus these tests must extend over long periods before the designer can use them with safety. Careful differentiation between applications as to required length of life of apparatus is necessary. The fact that a piece of equipment is operated at 1800°F. for a life of a few hours does not mean temperatures of that order can be used for heavy duty applications.

Present developments of the gas turbine are limited to the use of relatively high grade fuel oils. This one factor is a serious handicap to the gas cycle. The gas cycle is definitely limited in application until such time as the problems in connection with the burning of low grade oil and coal are successfully solved.

Present research efforts are being expended in war developments. In the postwar era industry will have access to the developments in the gas turbine field and to developments in high temperature materials. These developments may considerably change present thinking. It is safe to predict that general applications of the gas cycle must wait until the postwar era.

It will be wise to watch developments of early installations before attempting to make widespread applications. At present, conclusions as to the ultimate possibilities of the gas cycle are little more than good guesses. The gas turbine art must advance beyond its present early development stages, before it can be judged with assurance. However, undoubtedly it will find real usefulness in a large number of fields, possibly complementing rather than competing with the steam turbine. Just how and where the gas turbine will be applied, only time will tell.

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WHEN and WHERE To Build A Natural Gasoline Plant*

Factors are Reviewed which Require Management's Consideration before 'Yes' or 'No' is Given and Type of Plant Selected For Most Economic Operation

*By W. F. Matheny***

RATHER than to attempt a technical discussion of natural gasoline plant design on the basis of the familiar unit processes involved, I have taken the broader interpretation of my assigned subject to include a consideration of the long range operating and economic factors which affect the design of a modern gasoline plant.

After due allowance for minor differences in the detailed design of plant processes as we build them, or as you build them—differences traceable to the many personalities which have been involved in the development of our industry—there are no longer any important and generally unknown facts with respect to plant design and operation which one operator might have over another. Since the time when Mr. Kremser first explained his calculations and theory of absorption and Doctor Brown applied his equilibrium constants thereto, our younger engineers have calculated and reported on so many different operating combinations that the simple and respectable hydrocarbons of natural gas now have no secrets as to their behavior under various gasoline plant operating conditions.

Basically ours is still a salvage industry. As a general proposition we still gather the casinghead gas that is produced along with oil and, by the collection and stripping of this gas, returning to the leases residue gas over those periods when the wells are not flowing or pumping, we, in addition to paying for the gas, perform a service for the producers which they would individually find uneconomic or very inconvenient. However, even this salvage operation is nowadays run on a very scientific and business-like basis. Among the very many factors which must be considered before any gasoline manufacturer can ask his management to invest substantial sums of money in a gasoline plant are:

The areal extent of the producing horizon; well spacing; thickness, porosity, and permeability of the producing sand; reservoir temperatures and pressures; reserves of both gas and oil in place; gasoline content of the gas; nitrogen, carbon dioxide, and hydrogen sulfide content of the gas—not only at the time the plant is built but prophesied for every year of the field's life.

So far all these factors named lend themselves to fairly accurate determination. However, the real variables that make or break a gasoline plant situation do not lie within the gasoline manufacturers' control but must be fixed by the producers, and the regulatory bodies who in turn establish certain basic premises. I now refer to such things as allowables per well, whether the wells will be "stop-cocked" and the day's or week's allowable produced in a few hours; possibilities of pressure maintenance and, if such a program is to be followed, what per cent of the produced gas is to be injected into the sand, at what stages of depletion pressure maintenance is to be started and the possibilities of gas lifting in the final stages of natural flow, all of which are very vital factors to the gasoline manufacturers.

These producing methods in turn dictate the utilization of the residue gas and establish whether the plant operator can depend on some revenue from the sale of gas to help amortize his investment. Speculations as to prices of his products over the life of the project, the effect of income taxes on the earnings, and labor costs of the future must all be weighed into the melting pot from which the plant emerges. The southwestern oil fields are covered with vacant foundations which stand as monuments to the lack of those analyses or to the bad guesses on answers to some of the above questions.

TABLE I

(Composite of Several Low Temperature Fractional Analyses of Reservoir Gas and Liquid During First Year of Field Production.)

	Reservoir Gas Mol %	Reservoir Liquid Mol %
Methane	83.87	26.00
Ethane	9.26	9.07
Propane	4.00	7.55
Isobutane	0.50	1.60
Normal Butane	1.20	4.52
Pentanes	0.53	8.84
Hexanes and Heavier	0.64	47.42
	100.00	100.00
Bottom Hole Pressure, lbs. per sq. in		1600
Bottom Hole Temp., °F.		147
Molecular Weight of Hexanes and Heavier Fraction of Reservoir Liquid		205
H_2S Content of Separator Gas, grams per 100 cu. ft.		400

To point up the discussion and lend specificity to the data, we can set up a hypothetical reservoir and field, to which can be assigned reasonable characteristics and to which can be applied reasonable technology and economics. In this manner, we shall establish not only the mental mechanics necessary to the solution of a typical problem but we shall also lend a measure of perspective which may add value to the data. The data and derivations herein are purely illustrative, presented only to show one manufacturer's approach in determining the prospects of a sound venture, and followed by typical speculation as to the more important variables upon which any profitability is pitched.

For our purpose we shall simplify the presentation by assuming that the hypothetical field in question has been under development for one year, that its characteristics are already fairly well described, and that it is desired to begin gasoline plant operation at the end of the second year. The prospective plant operator evaluating the situation would have before him information such as given below on the field and reservoir and he would note the effect of the accuracy of such data on the eventual success of a gasoline plant venture about as indicated.

The field is described as having 5120 acres of proven production from a reservoir with an average sand thickness of 50 ft. and an initial pressure of 1600 lbs. Core data indicate about 20% porosity and a connate water content of about 20%. These facts would indicate over 300,000,000 bbl. of total hydrocarbon content but would not fully describe a gas-oil contact and could not be used to predict future field performance. Obviously, any inaccuracy in areal extent of the field, or pore volume would be directly reflected in the calculated total reserves.

Supplementing the sand volume data is the more pointed and useful information on the gas solubility and shrinkage characteristics of the reservoir oil, the produced oil and gas volumes and coincident bottom hole pressures at various times since first production, and the de-

*Presented before meeting of Natural Gasoline Assn. of America, Dallas, April 12, 1944.

**Superintendent, Natural Gas and Gasoline Department, Phillips Petroleum Co., Bartlesville, Okla.

viation of reservoir gas from Boyles law under reservoir conditions of temperature and pressure. For our example these data will show the reservoir to have initially contained 200,000,000 bbl. of "residual" or "stock tank" oil and 125,000,000,000 cu. ft. of gas. They will further indicate that no appreciable water drive exists and that a gas cap equal to 2% of the pore space initially existed.

Other Considerations Necessary

Considered in the light of the sand volume data this information would sound reasonable and could be used in prediction of reservoir performance. However, since the data reflect only a short period of operation, the presence or effectiveness of a water drive is by no means certain and future oil and gas production schedules must be considered only as estimates subject to later checking and revision.

Table I represents a composite of several low temperature fractional analyses of the reservoir gas and liquid during the first year of field production. At the conditions of sampling they indicate a saturated crude, and by flash vaporization of the reservoir liquid at bottom hole temperature the above quoted gas reserve of 125,000,000,000 cu. ft. is corroborated.

After determining that the reservoir and field development data are reasonably in accord, a forecast of the field operation under alternative production programs is permissible. Historically, natural gasoline plant operations have always been secondary in importance to oil production and the alternative programs available to us for study are no exception to the rule. We shall assume that the producers in our hypothetical field have elected a pressure maintenance program employing injection of 50% of the produced gas. Our problem is to analyze these alternative projects from the plant operator's standpoint to forecast the facilities and investment required during the life of the field and to estimate the costs of operation and return on the money invested.

The basic predictions of gas volume and composition which are required for plant design entail, of course, certain important premises of reservoir and field operation. Our figures reflect that:

(1) No water drive exists in the reservoir so that the only factors affecting the producing gas/oil ratio under efficient field operation are those of expansion and vaporization of the reservoir fluids.

(2) Construction will be completed and plant operation can begin at the end of the second year of the field life.

(3) A 69 bbl per well allowable will be effective during the prorated life of the field. (And Mister, a bad guess here can put you into bankruptcy).

(4) Field separators will operate at 5-lb gauge pressure and the plant intake pressure will be atmospheric.

(5) Production of oil and gas will be divided equally among all producing wells.

Fig. 1, based on an application of the accumulated physical data and the foregoing supplementary premises, is a composite of several curves showing com-

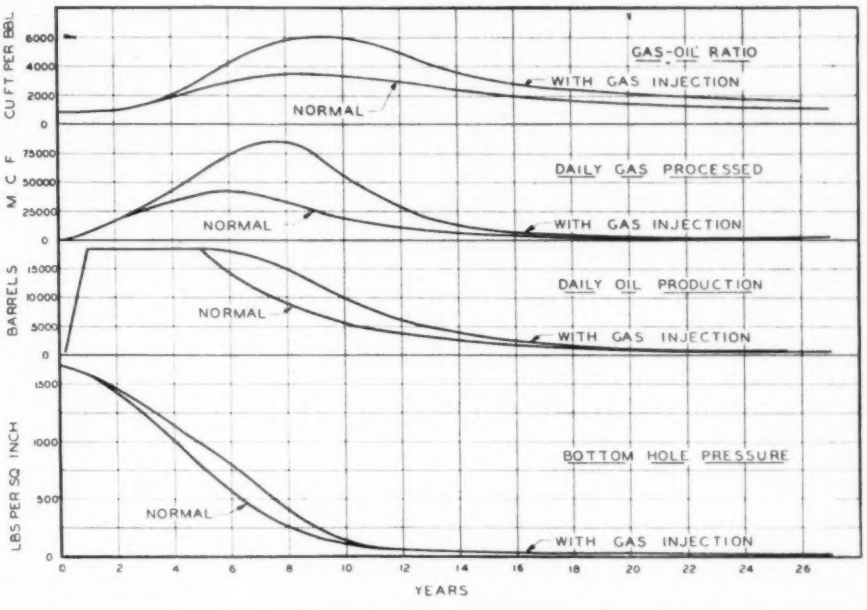

Fig. 1—Composite of several curves showing comparative operating data over life of hypothetical project

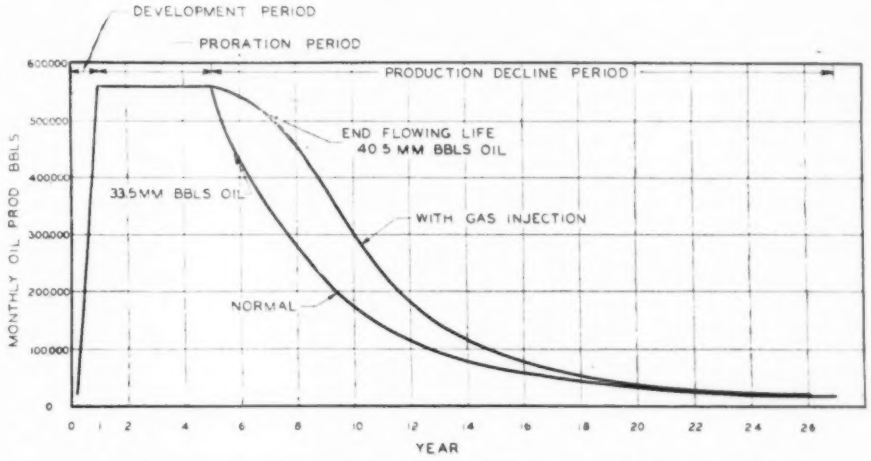

Fig. 2—General effect of pressure maintenance on oil production

TABLE II—Effect on Productivity from Assumption of 50% Reinjected Gas

	Daily Gas Vol. MCF	26-70 Gasoline in Gas, Gals.
With 50% gas injection; peak gas load 8th year	85,000	98,000
Without gas injection; peak gas load 6th year	42,300	72,400
Difference	42,700	25,600
% Increase	100%	35.3%
	Ultimate Gas Vol. Mª CF	**Ult. 26-70 Gasoline Recov. Gals.**
With 50% gas injection; complete life of plant	233,890	294,544,000
Without gas injection; complete life of plant	115,942	256,967,000
Difference	117,948	37,577,000
% Increase	100%	15%

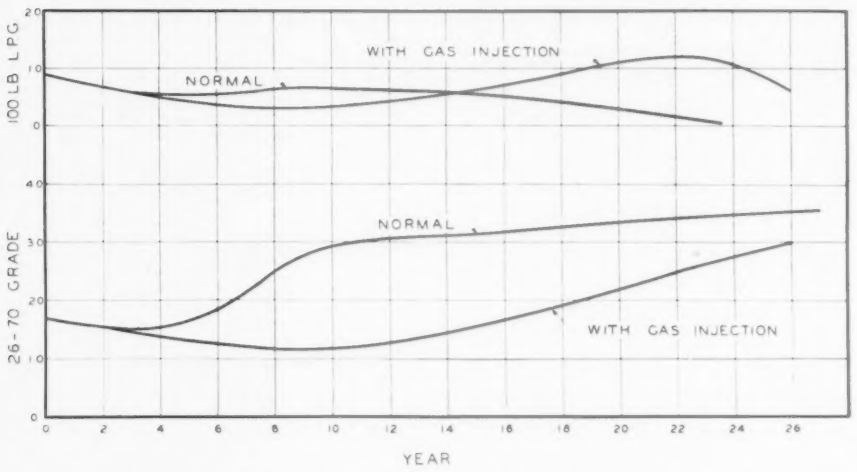

Fig. 3—Estimated plant yields of 26-70 grade natural gasoline and liquefied petroleum gas in gallons per M cu ft of gas

parative operating data over the life of the project. Future gas/oil ratios were determined from a simultaneous solution of material balance equations and the radial flow equations, using a relative permeability versus per cent saturation curve. Viscosity characteristics of the crude may be obtained experimentally in the laboratory. Viscosity of the gas is estimated, in this instance, along the lines set out by Sage and Lacey. Solubility and shrinkage data must be determined experimentally. The solution used was a trial and error method, using several pressure intervals until the reservoir is at zero pounds per square inch absolute. Note that the producing gas/oil ratio passes through a maximum under both the normal depletion and gas injection programs, and that gas injection both accentuates and displaces this maximum. Note also that the maximum daily volume of separator gas for processing is increased under the injection program to 85,000,000 cubic feet as compared to 40,000,000 under normal operation. Here, if one pauses for a quick overall look at the effects on the project from his assumption of 50% reinjected gas he will find results as shown in Table II.

Please observe here that the first two curves of Fig. 1, along with the assumed allowable per well, not only dictate the investment required, but the year in which it is to be made. The prudent operator derives a family of such curves based on more than one assumption as to allowables, per cent of gas reinjected, and the stage of depletion at which pressure maintenance might be started. Then, from past experiences with respect to operating practices of the producers involved, the past policies of the controlling regulatory bodies, and his own judgment—the plant and gathering lines are set up providing capacity for the immediate future, but with predetermined ideas as to future expansions.

For our example, the plant would start operations with only 2960 installed horsepower and one 1,350,000 gal distillation unit, though the plant layout would be adequate for 11,400 hp and four such distillation units. It is probable that all plant headers would, at the outset, be sized for the ultimate peak load with the attendant investment burden the first few years, but with future financial savings in both construction cost and shutdown time.

Effect of Pressure Maintenance

Although not essential to the solution of our problem, Fig. 2 is presented to show the general effect of pressure maintenance on oil production. The data are typical in showing an increasing monthly production during the development period before gas injection begins, a restricted maximum under proration, and a decline period during which allowables can no longer be met. The calculations in this instance, based on a termination of natural flow at a bottom hole pressure of 600 pounds, indicate that the 50% recycle gas injection program extends the natural flow period by 1.2 years, during which time 7,000,000 bbl of oil are produced. Ultimate oil recovery is increased by 20% or from 60,000,000 to 72,000,000 bbl by 50% gas injection.

Of greater importance to the problem at hand are the data of Fig. 3, which show the estimated plant yields of 26-70 grade natural gasoline and liquefied petroleum gas. The dilution effect of increased gas production is readily discernible in the lower 26-70 content under the injection program. The yield of liquefied petroleum gas, here estimated as the excess butane above 26-70 requirement resulting from 70% butane recovery plus sufficient propane to make 100 pound vapor pressure product, is at first lowered by the dilution effect of injected gas but is maintained after normal operation can no longer

A view of one of many plants, designed and constructed by Petroleum Engineering, Inc., in the past 15 years of continuous service to the industry. Petroleum Engineering, Inc. Offices: Tulsa and Houston.

Photographed for Petroleum Engineering, Inc.
By Robert Yarnall Richie

produce sufficient butane for 26-70 requirements.

Application of the yield data of Fig. 3 to the separator gas volumes shown in Fig. 1 develops the cumulative plant production data shown in Fig. 4. The 50% gas injection program increases 26-70 production 37,577,000 gal and increases L.P.G. by 26,193,000 gal. Examination will show that injection is quite ineffective in increasing natural gasoline production until the reservoir pressure has dropped to less than 500 psi and enrichment of the recycle gas becomes appreciable. The physical characteristics of the commingled injected residue gas and the reservoir oil at high pressures do not give the gas, on separation from the oil, many of the pentane-plus fractions which make gasoline. At lower pressures, such as would be experienced after the tenth year, the above would not be the case. Methane from the injected gas would go into solution with the crude oil to make up its existing vapor pressure and in turn "kick out" of the oil some of the fractions which make natural gasoline. This characteristic is shown clearly on the G.P.M. curve in Fig. 3. During the period of early injection with high bottom hole pressure and increasing ratios, the G.P.M. yield of the 26-70 grade will be driven down perceptibly.

When to Repressure?

The content makes its recovery only when the ratios have diminished, the bottom hole pressure is sufficiently low for the exchange in hydrocarbons between the injected gas and the oil contacted and the richer gas is evolved from the oil in place at the lower bottom hole pressure. Unfortunately, when the reservoir pressure has declined to the extent that injected gas would be enriched with natural gasoline hydrocarbons, the pool's gas reserve will have been dissipated and the available volume of gas for injection will be very small. Thus it is quite obvious that the stage of depletion at which pressure maintenance might be started and the percentage of produced gas to be returned to the sand have a profound effect on the gasoline plant situation.

In addition to forecasts of field and reservoir performance, management must have before it the requirements of equipment and capital expenditure necessary to obtain the production and income. What benefit is an extensive operation and large production if operation costs and taxes preclude a reasonable profit to the enterprise? The elements of difference in equipment and operation must be reviewed in order to determine the respective investments required and the return to be expected.

TABLE III

(Summary of Compressor Horsepower Requirements*)

Year	Field Engines For Normal Reservoir Depletion Program	Field Engines For 50-lb. Plant When Employing Gas Injection
3	2,780	2,960
4	3,720	4,340
5	4,950	6,520
6	5,700	8,800
7	5,400	10,700
8	4,710	11,400
9	3,880	11,000
10	2,910	8,730
11	2,160	6,600
12	1,640	4,620
13	1,220	2,910
14	935	2,240
15	715	1,580
16	567	1,115
17	447	804
18	357	585
19	284	470
20	233	382
21	193	318
22	...	280
23	...	211

*Based on 75% load factor.

TABLE IV

(Compressor Load Factors)

	1944 January	1944 February
Mankins Plant (K.M.A.)		
Daily Average Gas (MCF)	14,559	17,033
Peak Recorded Gas (MCF)	18,292	20,072
Apparent Load Factor*	79.5%	85%
Goldsmith Plant		
Daily Average Gas (MCF)	45,941	48,530
Peak Recorded Gas (MCF)	59,452	63,105
Apparent Load Factor**	77.3%	76.9%

*Actual load factor is lower since peak recorded gas is based on average of a 48-hour chart reading.

**Actual load factor is lower since peak recorded gas is based on average of a 24-hour chart reading.

Table III summarizes the horsepower requirements for field gas compression during the probable economic life of the project. Both the temporarily large gas volumes and the low load factor characteristic of the premised operations are effective in making the engine horsepower high. The summary as shown depicts a best estimate of rigorous adherence to the problem premises as set up for study in that it provides for handling of all of the produced gas from 5-lb pressure separators in order that the 26-70 and L.P.G. which have been considered as available from the total gas may be produced. Actually, the high peak volumes are of such short duration that it may not be profitable to install the necessary horsepower to handle all of the gas.

Engine Requirements

In estimating engine requirements it would, of course, be highly desirable to reflect some satisfactory agreement between the producers and the plant operator with respect to an even hourly and daily flowing schedule. Even though the volumes be large and the gas be rich with gasoline, if production is limited to the daylight hours or to the minimum days at the first of each month necessary to make the oil allowable, there is no profit in the gasoline plant operation. The horsepower specified in Table III is based on an operating load factor of 75%, which appears at first glance to be low but which has in fact been repeatedly exhibited by actual operation. Table IV reports actual load factors from 77 to 85% based on the average peaks indicated by 24 and 48 hour meter chart volumes. Hourly load factors would, of course, be lower.

As to the plant proper, Fig. 5 shows the familiar low pressure absorption type plant, designed in this instance to handle efficiently the gas volumes encountered under normal reservoir depletion. In order to minimize hydrogen sulfide corrosion troubles in the gathering system and plant, the field compressor suction is maintained at atmospheric pressure to prevent air infiltration. Compressor discharge and absorber pressure are at about 50 lb. The natural gasoline production is fractionated and treated to produce a 26-70 grade product and 100 lb vapor pressure butane-propane mixture. Such residue as is needed for fuel purposes is treated for hydrogen sulfide removal.

As far as management is concerned, all of the information with respect to reserves and a production schedule, field operating characteristics and peculiari-

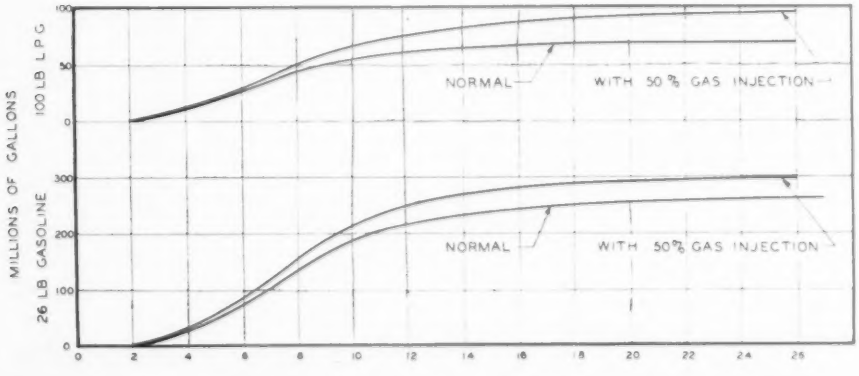

Fig. 4—Cumulative data on plant production of 26-70 grade natural gasoline and liquefied petroleum gas

ties, and plant design is collected and assimilated for but one purpose—to judge and weigh the effects on the amount and time of investment and income. The ultimate province of management in the industry is to combine this information into schedules covering the life of the project and to add thereto a judgment of future product salability and value, operating costs, and taxes to arrive at a net income, and a probable economic life. The susceptibility of such information to various interpretations by different individuals, motivated by optimistic or pessimistic instincts, gives rise to the lively competition of the business.

By way of illustration, an estimated investment summary can be made by years of the plant project for the normal reservoir depletion and for the pressure maintenance program.

Plant balance sheets can be extended over the probable life of the project, from which the payout periods and an average annual rate of return on the investment can be taken. Such an analysis will reflect the net income per unit of investment for the pressure maintenance case to be substantially less than that obtained under normal depletion in spite of the increased production.

Disregarding those factors of ideality which apply to either project under consideration, and which render each project somewhat unrealistic, management now has sufficient information for a project comparison which may be reduced to a single statement with respect to each.

The Gas Contracts Problem

Now that the situation appears a desirable one to control, that ghost of the industry—competition for gas contracts—appears. It is almost too much to even hope that one plant would serve such a field, but instead the contracts would end up in the hands of two or three concerns whose duplication of both investments and operating expenses further hazard the profits therefrom. However, once this feature of the enterprise is settled, the data are again reviewed, adjusting the design to the new conditions, and adding many refinements such as

(1) A thorough analysis of field line sizes to determine whether the last increments in pipe diameter are justified for the proportionate part of the day actually needed. Quite frequently it becomes necessary to vent a part of the gas supply during periods of high hourly production rate, and such conditions must be interpreted into both the investments and operating income.

(2) A similar analysis of the compressor requirements—taking into account each year the producing practices of the operators.

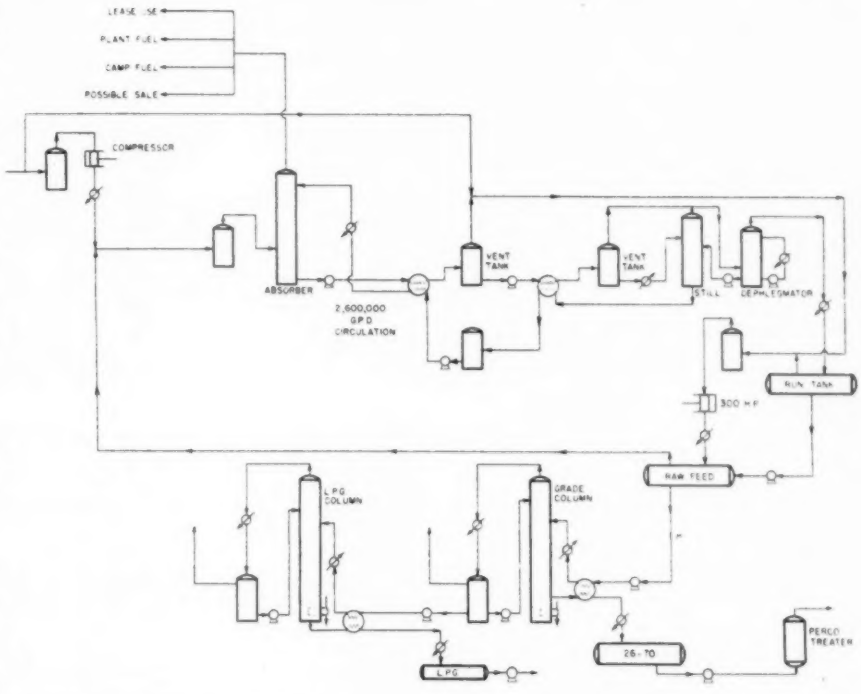

Fig. 5—Typical low pressure absorption type natural gasoline plant, with no gas injection

(3) A similar analysis of oil circulating requirements—prophesying requirement in advance of each year. Peak loads of short duration, whether distributed over the hours of the day or due to the stage of depletion, must be carefully watched to avoid the installation of equipment that has little productive life.

(4) A carefully estimated summary of surplus residue gas that might be available for sales, and a canvass of possible markets for its disposition.

(5) A study of markets for 26-70 grade natural gasoline, liquefied petroleum gas and prospects for segregation of isobutane.

Before closing, I want to say a few words about the plant operators' contribution to any pressure maintenance program, and perhaps sound a prophetic note about things to come. The decided advantage of conservation of energy and increased oil recovery has been excellently demonstrated time and again by various producers. Within the near future new pressure maintenance projects—on a relatively large scale—will be instituted, and within a short time practically every new field will be so operated.

By virtue of the nature of their respective businesses, it is inherent that each can contribute substantially to the other in a pressure maintenance or repressure program. In our example the plant operator has installed an adequate gas gathering system and 11,400 hp which are as serviceable to the producer in his injection program as though he owned them. The presence of an engine room with trained men places the plant operator in a position to perform the boosting services more efficiently and safely, and at a substantial saving to the producer.

It is only natural that producers reinjecting gas into the sand are much more concerned with an even supply of residue, which is reflected in flowing schedules that permit the boosting facilities to stay loaded over the 24-hour period. This one item is quite often the difference between profit and loss to the gasoline manufacturer. Also, if the absorption system can be built on the intermediate or high stage side of the booster, plant distillation equipment can be reduced roughly in proportion to the absorption pressure. This is a substantial saving to the plant in both investment and operating costs, and effects a decided reduction in boiler fuel which is thereby made available to the producer for injection.

Having no voice as to the volumes, location, nor time such an operation is to be carried on, and a relatively minor interest in the profits to be derived, the gasoline plant operator must depend upon the producers to underwrite his investments in pressure maintenance equipment. But he should in turn be ready to perform such services for a small margin of profit above actual costs and amortization. It is my opinion that practically all gasoline plant operators have evinced their adoption of such a policy.

New Theories on Catalytic Cracking Presented at A.C.S. Meeting*

Formation of Catalyst Deposit Claimed Essential For Hydrogen Transfer Reactions Involving Conversion of Olefins to Paraffins

THE carbonaceous deposit formed on catalysts in cracking operations has usually been thought of as a necessary nuisance. Recent investigation, however, has shown this catalyst deposit to be an integral part of the cracking reaction, and it now appears that it is essential for reactions involving the saturation of olefins by means of hydrogen transfer.

Formerly, hydrogen transfer was thought to be the result of a loss of hydrogen by hydroaromatic hydrocarbons (which were converted to aromatic hydrocarbons), with the resulting hydrogen attaching itself to the olefins to form isoparaffins.

The yield of aromatic hydrocarbons, however, did not account for sufficient hydrogen to effect the isoparaffin yield. It was then suggested that some of the hydrogen needed to convert olefins to isoparaffins was made available by the formation of a hydrogen-deficient catalyst deposit.

This explanation of hydrogen transfer and details of the research work behind it were described before the Petroleum Division of the American Chemical Society at their meeting in Cleveland, April 3-6, by Charles L. Thomas of Universal Oil Products Co., Chicago.

In the opening portion of his talk, Mr. Thomas explained that "while studying the practical applications of catalytic cracking, it was found that when an olefin-containing gasoline that has been produced by catalytic cracking was again contacted with the cracking catalyst the olefin content of the gasoline decreased, while the isoparaffins and aromatics increased. This action suggested that hydroaromatic hydrocarbons were present in the gasoline and that these lost hydrogen to form the aromatic hydrocarbons, while the hydrogen that was thus made available reacted with iso-olefins present to form isoparaffins. Consequently, the reaction was called 'Hydrogen Transfer'. It was also found that the hydrogen transfer reaction could be aided by adding higher boiling (above 200°C.) petroleum fractions that should contain considerable quantities of cyloparaffins."

But certain of the results obtained with gasolines, Mr. Thomas stated, were not readily explainable by such a simple hypothesis. "More hydrogen seemed to be used in saturating the olefins than was available from the cycloparaffins present, so the cycloparaffins appeared to be helpful if present but not essential." It was then suggested that the formation of the catalyst deposit with a low C:H ratio was the explanation of the source of the "unaccounted for" hydrogen.

The investigations and research work that Mr. Thomas described at the meeting were concerned with the reactions of *n*-octenes under conditions such that the formation of paraffinic products was the major reaction. The test was conducted at 375°C. and a pressure of 8 kg/sq cm absolute. A silica-alumina-zirconia catalyst (U.O.P. Type B) was used.

It was found in this study, Mr. Thomas pointed out, that paraffinic and aromatic products were formed in the absence of added cycloparaffins. And, as previously noted, all of the paraffinic products produced could not be explained by the yields of aromatics isolated. But "by taking into account the yield of catalyst deposit and its C:H ratio, a reasonably satisfactory explanation of the yield of paraffinic products was obtained," he explained. "Thus the hydrogen transfer reaction is considerably more complex than the simple transfer of hydrogen from hydroaromatic to olefin hydrocarbons."

A summary of the experimental conditions and yields of gas, liquid and catalyst deposit is given in Table 1. Table 2 summarizes the results of the fractionation and gives the analysis of the liquid products, while Table 3 presents the gas analysis. From the results in Table 2 it has been calculated that approximately 60 Wt. per cent of the liquid products are paraffinic, and Table 3 shows that 69 mol per cent of the gaseous products are paraffinic.

The reactions of *n*-octenes under the conditions of this test as described by Mr. Thomas were as follows:

1. **Hydrogen transfer.** These reactions resulted in the conversion of olefins to paraffins; at the same time products poorer in hydrogen, such as aromatic hydrocarbons and the catalyst deposit, were formed.

2. **Isomerization.** Earlier work° showed that *n*-octenes isomerized rapidly in the presence of this type of catalyst. In the present test the iso-C_8 fraction constituted 93% of the C_8 cut.

3. **Scission of carbon-carbon bonds.** Products containing fewer than eight carbon atoms were formed; the tendency of this type of catalyst to form cracked products containing three or more carbon atoms was again demonstrated.

4. **Polymerization or condensation.** Products containing more than eight carbon atoms were formed; these products included higher boiling liquids as well as the solid and semi-solid material deposited on the catalyst.

5. **Cyclization.** Aromatics within the boiling range of the xylenes as well as still higher boiling aromatics were formed. The formation of the aromatics may have been preceded by the formation of the corresponding cycloparaffin. The evidence for the presence of the cycloparaffins is less convincing than that for the aromatics.

"In spite of the uncertainty as to the composition of the high boiling aromatic products," Mr. Thomas claimed, "it seems clear that at least 50% of the hydrogen required for the formation of the saturated products is accounted for by the hydrogen-poor catalyst deposit. Before this observation was made, there

TABLE 1**

Experimental Conditions and Products	
Experimental Conditions:	
Furnace Temp., °C	375
Abs. Press., Kg/sq cm	8
Liquid Hourly Space Velocity	0.86
Duration of Run, Hours	1
Total Vols. Chg./Vol. Catalyst	1
n-Octenes Charged, grams	286
Catalyst Used, grams	320
Catalyst Used, cc	400
Products, Wt. % of Charge:	
Gas	12.9
Liquid	79.3
Catalyst Deposit	12.6
TOTAL	104.8
Unaccounted Gain	4.8

**The table numbers, titles and contents do not in all cases correspond with the original tables presented by Mr. Thomas.

°G. Egloff, J. C. Morrell, C. L. Thomas and H. S. Bloch, J. Am. Chem. Soc. 61, 3571 (1939).

TABLE 2—Analysis of Liquid Products

Fraction	B. P., °C.	Wt. %	Br. No.	% Olef.	% Arom.	% Par.	% Naph.
C_5	10-40	13.5	50	22	0	78	0
C_6	40-70	5.4	53	28	0	72	0
C_7	70-95	3.6	44	27	0	63	10
i-C_8	95-120	51.2	41	28	0	64	7
n-C_8	120-125	4.0	50	35	4		
C_9	125-150	5.8	33	26	22	51	1
Bottoms	>150	16.6	17	18°	31-71†	11-51†	
Total Liquid				26	7-13	55-63‡	4-13‡

°—As C_{12}.
†—Depending upon whether aromatics are mononuclear or dinuclear.
‡—Sum of paraffins and cycloparaffins is 61%.

*Condensed from a paper on "Hydrocarbon Reactions in the Presence of Cracking Catalysts. II—Hydrogen Transfer", presented before the Petroleum Division, American Chemical Society, Cleveland, April 6, 1944, by Charles L. Thomas, Universal Oil Products Co., Chicago.

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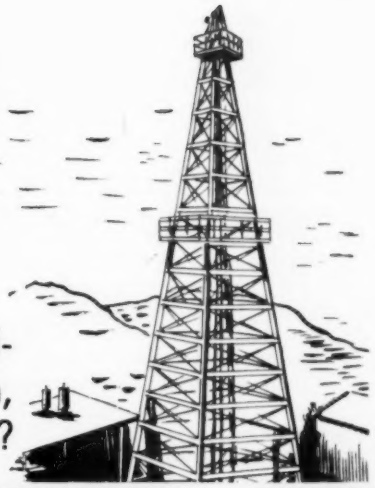

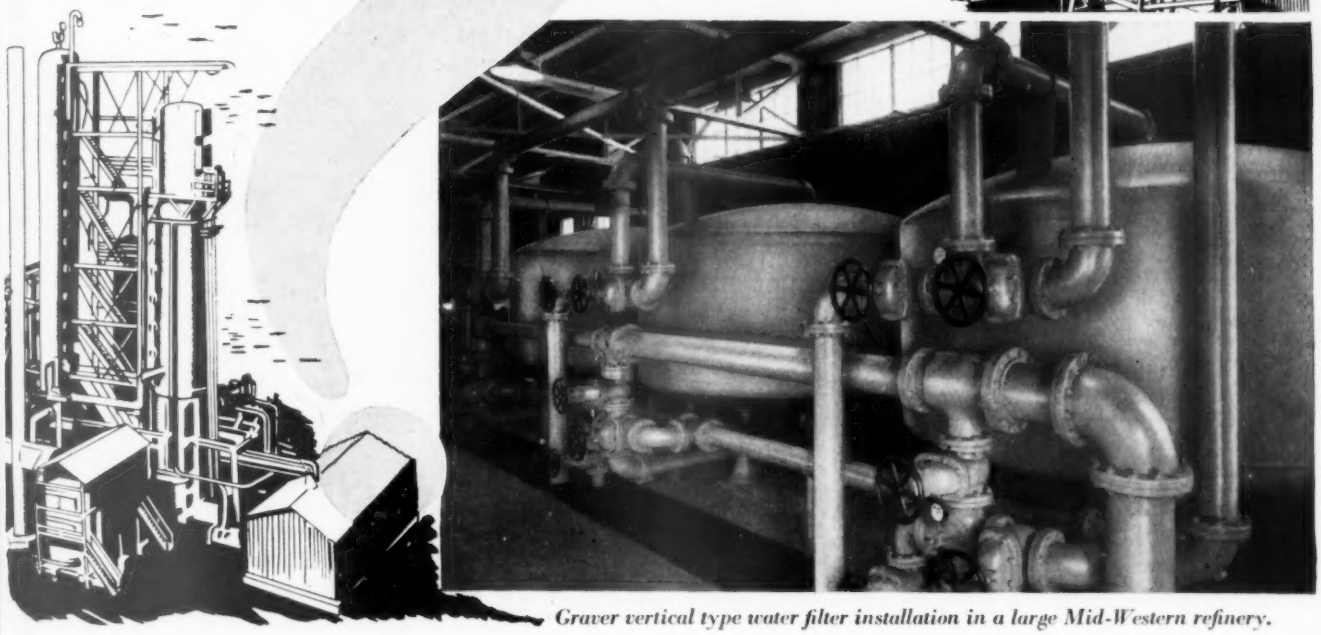

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had been a tendency to regard the catalyst deposit as a necessary nuisance which resulted from side reactions. The present work establishes the fact that the catalyst deposit can be formed as an integral part of the reaction, and the products associated with its formation are often desirable."

The nature of the catalyst deposit was investigated in some detail. Combustion analyses made on the spent catalyst indicated that the deposit had the approximate composition $(C_3H_4)_n$.

Exhaustive extraction of the spent catalyst with benzene removed 27.6% of the deposit as a viscous, semi-solid tar. This benzene-soluble portion was separable into an acetone-soluble fluid tar (40%) corresponding approximately to the formula $C_{16}H_{18}$, and a relatively acetone-insoluble red-brown powder (60%) which, after reprecipitation from chloroform and petroleum ether, proved to have approximately the formula $C_{32}H_{28}$.

TABLE 3

Analysis of Gaseous Products

Fraction	Mol %
H_2	1.4
CH_4	2.9
C_2H_4	0.6
C_2H_6	1.7
C_3H_6	11.6
C_3H_8	11.2
$i\text{-}C_4H_8$	5.4
$n\text{-}C_4H_8$	11.9
C_4H_{10}	53.2

The non-extractable catalyst deposit (72.4%), upon combustion analysis, showed the composition $(CH_{1.42})_n$, so that the weighted average of the three portions analyzed corresponded to $(C_3H_4)_n$ in excellent agreement with the original combustion analysis of the total catalyst deposit.

The results of the carbon and hydrogen analysis of the catalyst deposit are given in Table 4.

"Although it is possible that the unextractable portion is richer in hydrogen than the extractable fraction, and is insoluble merely because of a higher molecular weight," Mr. Thomas pointed out, "it is considered more likely that there is a fixed amount of moisture in the spent catalyst which causes a small constant hydrogen error in the combustion analyses of the catalyst. If this latter interpretation is correct, the catalyst deposit has less hydrogen than the formula $(C_3H_4)_n$ indicates, and the formation of such material liberates more hydrogen for hydrogen transfer than is indicated in the hydrogen balance of the reaction products."

"There are processes for making aviation fuels," he continued, "in which gasolines containing olefins are contacted with cracking catalysts at temperatures in the range of 350° to 525°C. and at pressures somewhat above atmospheric to produce an improvement in the antiknock quality. The olefin content of the gasoline is reduced, the aromatic content increased and the susceptibility to lead tetraethyl improved. The reactions described in the present work aid in understanding the chemistry of these processes."

TABLE 4—Analysis of Catalyst Deposit

Material	Wt. of Sample, mg.	Wt. of CO_2, mg.	Wt. of H_2O, mg.	Wt. of Carbon, %	Wt. of H_2, %	Molec. Wt. (Ebullioscopic)	Formula Calculated
Spent Catayst	479.6	198.2	53.8	9.34	1.03		$CH_{1.31}$
Acetone-Insoluble Extract	2.707	9.112	1.63	92.97	6.82	396,431	$CH_{0.875}$
Acetone-Soluble Extract	2.701	9.079	2.042	91.68	8.46	202,224	$CH_{1.10}$
Extracted Catalysts	491.5	124.5	36.2	6.89	0.819		$CH_{1.42}$

American Chemical Society Abstracts

Catalytic cracking and alkylation were the predominate subjects discussed before the Petroleum Division of the American Chemical Society at the group's annual spring meeting in Cleveland, April 3-6. The official A.C.S. abstracts of most of these papers are given below.

Discussion from the floor was noticeably lacking after many talks. As explained by one member: "Most of us here probably know a great deal more about these subjects than appears on the surface. And our reticence to discuss them stems more from a desire not to reveal information of a restricted nature than lack of interest."

Combustible Gases as Substitute Motor Fuels

Gustav Egloff and Mary Alexander, Universal Oil Products Co., Chicago

Combustible gases have replaced over 3,000,000 barrels of gasoline in the operation of about 140,000 motor vehicles in Europe, since these gases come from domestic sources. Even in the U. S., propane and butanes are used in about 25,000 vehicles. Methane, ethane, propane and the butanes are obtained from oil and natural gas wells, refineries, coal mining and processing, sewage and city gases. Acetylene, ammonia and hydrogen are used in countries particularly where there is abundant water power to furnish electric energy. Utilization of all these fuels has been limited in Europe, since high-pressure equipment requires materials of which there is a shortage. Although at present the equipment is much heavier, the fire hazard greater and commercial distribution poorer than with gasoline, gases may play an important role in the future of motor transport.

Phase Equilibria in the Ethane-Ethylene-Acetylene System

J. Lloyd McCurdy, Standard Oil Co., Cal., and D. L. Katz, U. of Michigan

An experimental study of the phase equilibrium relationships of the ethane-ethylene-acetylene system has been carried out at two temperatures, 40° and 60°F., and at a series of pressures in 50-pound intervals covering the entire two-phase region at each temperature.

The constant-boiling mixtures of the ethane-acetylene and ethylene-acetylene system persist through the triangular three component diagrams. At constant temperature and pressure these diagrams have two two-phase areas. Acetylene is the most volatile constituent in one area and the least volatile in the other area.

Correlation of Vapor-Liquid Equilibria Data

C. O. Miller, Case School of Applied Science, and R. C. Barley, E. B. Badger & Sons Co.

It has been found empirically that for the *n*-paraffin hydrocarbons from propane through *n*-octane the vapor fugacity is a single function of total pressure. It was known previously that for a given substance liquid fugacity is a single function of temperature. By employing these two relations, values derived from the experimental vapor-liquid equilibria data of Katz and Hachmuth have been correlated. The correlation is presented in the form of an alignment chart with scales for temperature, pressure, and equilibrium constants, and points representing various light hydrocarbons.

Vapor Pressures in Hydrocarbon-Furfural-Water Systems

Clark Holloway, Jr., and S. H. Thurber, Gulf Research & Development Co., Pittsburgh

Systems of four hydrocarbons with a furfural-water solution have been studied with respect to cloud point, vapor pressure, and density. Isobutane was found to be the least soluble in the 4 weight per cent water—96 weight per cent furfural mixture, followed by *n*-butane,

butene-1, and butadiene-1, 3. Isothermal vapor pressure and density data were also taken at four temperatures above the cloud point curves: 250°, 200° 150° and 100°F. These vapor pressure data permitted the calculation of activity coefficients which are presented as plots of γ versus x for each system at the four temperatures listed. Experimental vapor pressures for butene-1 and butadiene-1,3 are given up to 250°F.

Selectivity of Solvents for Various Types of Hydrocarbons as Measured By Critical Solution Temperature

Alfred W. Francis, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

Critical solution temperatures have been determined for over 100 solvents of various types with ten representative hydrocarbons, two straight-chain paraffins, a branched-chain paraffin, two olefins, two naphthenes, paraffin wax and two commercial oils. Aromatic hydrocarbons are too miscible with these solvents to obscure the critical solution temperature.

The differences in C. S. T. for the same solvent with different hydrocarbons is taken as a measure of the relative affinity or selectivity of the solvent for the two types of hydrocarbon. Selectivities for olefins, naphthenes, branched chains, type of oil, and molecular weight are calculated and plotted against each other to show their extent of interrelation.

Effects of substituent groups in the solvents are estimated. The methyl and phenyl groups usually lower the C. S. T. about 40°C. The nitro and carboxyl groups raise it over 100°C.

A Simple Test for Measuring the Corrosivity of Used Engine Oils

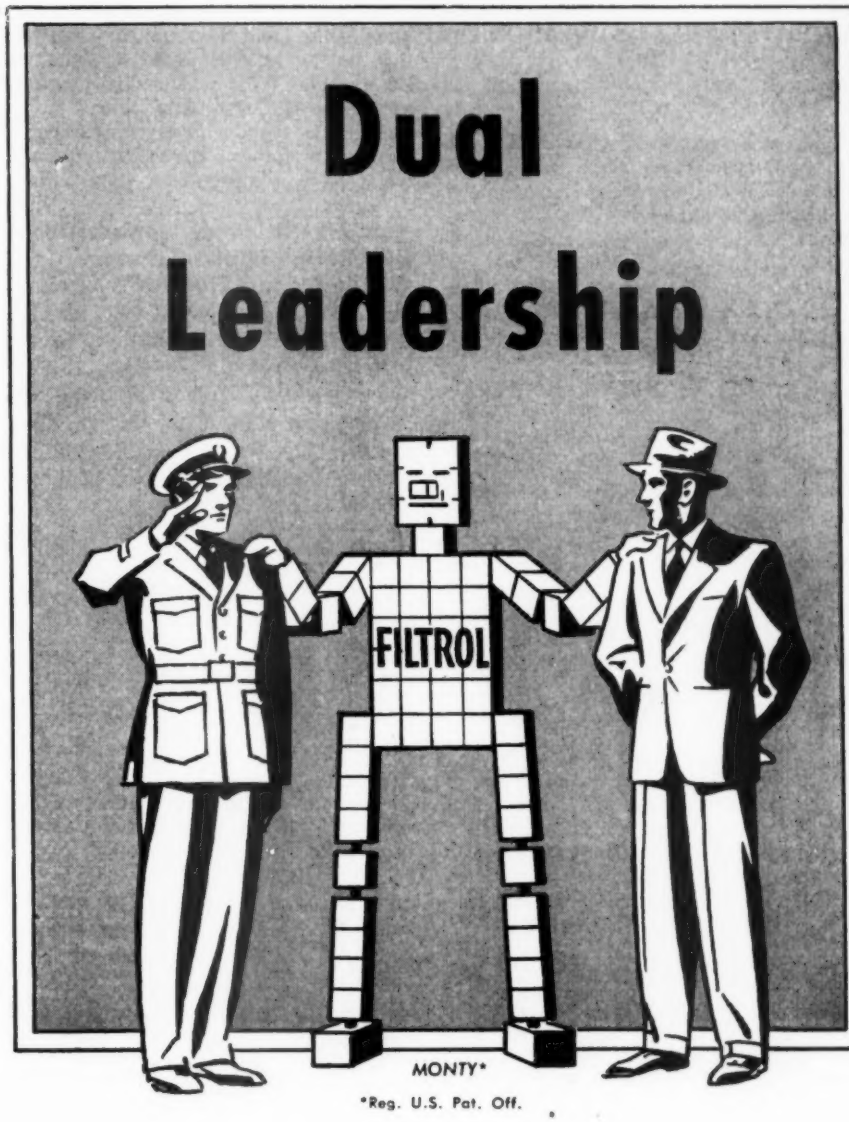
R. G. Larsen, F. A. Armfield and L. D. Grenot, Shell Development Co., Emeryville, Calif.

A test for determining the corrosivity of used engine oils independently of previous history has been devised. The test provides a means for evaluating in simple fashion, by the use of test strips coated with lead or other metal in graduated thicknesses, a property of used oils not heretofore satisfactorily measured by routine engine oil tests. It also has practical application in determining the cause of bearing failures and indicating necessary oil drain periods. The relation between the property measured and the usual engine inspection data is discussed.

Hydrocarbon Reactions in the Presence of Cracking Catalysts. III—Cyclohexene, Decalin and Tetralin

Herman S. Bloch and Charles L. Thomas, Universal Oil Products Co., Chicago

A study was made of the reactions, at atmospheric pressure, of cyclohexene in the presence of a synthetic silica-alumina-thoria catalyst at 250°-400°; of tet-



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ralin with a synthetic silica-alumina-zirconia catalyst at 400°-500°; and of decalin with the latter catalyst in both the fresh and partially spent state at 400-500°.

The principal reaction products isolated from cyclohexene were methylcyclopentenes-1 and -2, methylcyclopentane, a mixture of unidentified liquids boiling higher than cyclohexene, and 2, 6-dimethylnaphthalene. The principal reactions of cyclohexene under the conditions studied were (1) isomerization, (2) polymerization, and (3) hydrogen transfer. The hydrogen transfer was primarily from the polymer resulting in the formation of dimethylnaphthalenes and the hydrogenation of the methylcyclopentenes to methylcyclopentane.

Naphthalene was the product formed most abundantly from tetralin. Scission of the hydroaromatic ring gave benzene, toluene, xylenes, possibly ethylbenzene, and higher boiling alkylated benzenes. No alkenylbenzenes were isolated. They might have been formed and then converted into the corresponding alkyl derivatives by hydrogen made available by the conversion of tetralin to naphthalene. Some of the tetralin was converted to bicycloparaffins, presumably decalin or its isomers. The products can be explained by reactions of (1) scission of the hydroaromatic ring and (2) hydrogen transfer. Apparently isomerization also occurred, for the xylene fraction contained xylenes other than *o*-xylene.

The chief products formed from decalin were decalin isomers, C_3 and C_4 olefinic and paraffinic gases in which isobutane predominated, methylcyclopentane, and probably cyclohexane and the corresponding olefins. In addition, tetralin or its isomers was found, and the aromatic reaction products of tetralin conversion indicated above. The products can be explained by the following reactions of decalin and the intermediate tetrolin: (1) isomerization, (2) ring scission, and (3) hydrogen transfer.

Hydrocarbon Reactions in the Presence of Cracking Catalysts. IV—Removal of Side Chains from Aromatics

Charles L. Thomas, James Hoekstra, and John T. Pinkston, Universal Oil Products Co., Chicago

The cracking of ethylbenzene, cumene, *n*-butylbenzene, and technical amylbenzene in the presence of synthetic catalysts of the silica-alumina type was studied in the temperature range of 400° to 500°C. and atmospheric pressure. Benzene and the corresponding alkene were formed with ease and great selectivity when the side chain contained three or more carbon atoms. The yield of benzene was at least 90% of theory in each case. The order of decreasing susceptibility to cracking was cumene, the technical amylbenzene, *n*-butylbenzene, and in a lower order of magnitude, ethylbenzene. No toluene, styrene, etc., was found in any product in this study.

The alkenes formed apparently underwent subsequent reactions to some extent, for some hexenes were formed in the cumene tests, presumably by polymerization of the initially formed propylene. The olefinic products from butylbenzene underwent the hydrogen transfer reaction; some butanes were formed.

The Alkylation of Isoparaffins By Olefins in the Presence Of Hydrogen Fluoride

Carl B. Linn, Universal Oil Products Co., Chicago, and Aristid V. Grosse, Catalytic Development Co. (Contribution of Universal Oil Products Co.)

Hydrogen fluoride catalyzes the interactions of olefins and isoparaffins to form saturated products consisting of highly branched paraffinic hydrocarbons. The alkylation was carried out, both in continuous and batch operations, in the laboratory. The effects of temperature, contact time, isoparaffins to olefin ratio, and catalyst concentration were studied.

Runs involving the paraffins isobutane and isopentane, and the olefins, propene, isobutylene, butene-1 and butene-2, are reported; also the production of alkylate from a mixture of butanes and butylenes.

Normally the fluorine content of the alkylate is low and can be reduced by further treatment.

Reaction of Methylcyclopentane with Olefins in the Presence of Sulfuric Acid and Hydrogen Fluoride Catalysts

Herman Pines and V. N. Ipatieff, Universal Oil Products Co., Chicago

The study of the reaction of cycloparaffins with olefins was undertaken in order to gain a better understanding of the alkylation reaction, since the ring hydrocarbons can readily be detected and identified.

For this study, methylcyclopentane was chosen as the hydrocarbon to be alkylated in preference to the more accessible cyclohexane, for the reason that it undergoes alkylation more readily and at the same time it permits observation of whether or not isomerization of the cyclopentane to cyclohexane ring occurs. It is known that at room temperature the equilibrium is mostly toward cyclohexane side. Alkylation with the following olefins was investigated: Propene, *n*-butenes, isobutylene, pentene-2, 3-methylbutene-1, and 2,4,4-trimethylpentene-1 and -2. The alkylation was carried out in the presence of sulfuric acid and hydrogen fluoride, since these two catalysts, under the experimental conditions used, cause practically no isomerization of saturated hydrocarbons.

It has been found that the reaction of methylcyclopentane with olefins is accompanied by a complex reaction involving (a) addition of olefins to methylcyclopentane accompanied by ring expansion and migration of alkyl groups within the ring, (b) hydrogen disproportionation, the naphthenes being usually the hydrogen donors; whereas the olefins are the hydrogen acceptors, (c) isomerization of normal chain olefins to iso-olefins followed by hydrogenation, (d) interreaction of partially dehydrogenated naphthenes to form polycyclic olefinic or polycyclic saturated hydrocarbons, (e) depolymerization and/or depolyalkylation. The ease with which the above-mentioned reactions occur depends to a great extent upon the olefins used. The unsaturated hydrocarbons formed during the reaction are usually found in the catalyst layer, from which they can be recovered by diluting with water.

Conversion of Hydrocarbons Into Butadiene—1, 3*

Gustav Egloff and George Hulla, Universal Oil Products Co., Chicago

All ordinary hydrocarbons can be converted into butadiene-1,3, in yields varying from traces to 100% according to their structure. The underlying processes are:

(1) Thermal treatment of alkanes, alkenes, alkadienes, cyclanes, decahydronaphthalene, cyclohexenes, benzene, petroleum and its fractions, natural gas, cracking gases, natural rubber, and the "butadiene rubber" obtainable from vinyl bromide. In thermal conversion, higher yields are obtained from alkenes (5 to 55%) than from alkanes (1 to 5%). This phenomenon is ascribed to general use of too low temperatures, which in the case of alkenes are mitigated mainly by structural weakening of bonds in beta position to the C=C group. The endothermic character of butadiene-1,3 probably demands temperatures around 1400°C., rapid quenching of products, and provisions against formation of ethyne and benzene.

(2) Catalytic cracking of 2-methylbutane, *n*-butenes, cyclohexane (41.9% yield), cyclohexene (56% yield on recycling), benzine, and gas oil. (3) Dehydrogenation of *n*-butane and the *n*-butenes in presence of catalysts. Extensively utilized in the United States. Chlorine can be used as a reactant, forming hydrogen chloride. (4) Isomerization of butadiene-1,2, butyne-1, butyne-2, methylenecyclopropane, and 1-methylcyclopropene. A promising set of processes. (5) Condensations of ethene with itself or with ethyne. (6) Hydrogenation of butenyne and butadiyne. High yields in both cases. (7) Electrical treatment of alkanes, ethene, ethyne and kerosene. Various types of silent electrical and spark discharges are used. (8) Partial oxidation of gaseous alkanes, ethene, butene-2, cyclohexane, cyclohexene, benzene; toluene, naphthalene, petroleum naphtha, crude petroleum, and tar oils.

n-Butane, ethene, *n*-butenes, butenyne, butynes, butadiyne, cyclohexane, cyclohexene, and 1-vinylcyclohexene-3 are highly convertible hydrocarbons because their electronic and molecular structures approach those of one or more of some 18 resonance forms of butadiene-1,3.

* This paper was presented before the Division of Organic Chemistry of A.C.S.

Key Technologists in New Wartime Plants

The Pure Oil Co. War Products Plants

THE PURE OIL CO. has a large stake in the production of war products from petroleum, including in its owned facilities codimer units at Cabin Creek, W. Va., Heath and Toledo, Ohio; hydroformer and toluene extraction units at Toledo; catalytic cracking, alkylation and isobutylene units for 100-octane gasoline production at Smiths Bluff, Texas. In addition, its Cabin Creek refinery is producing aviation lubricants and Navy fuel oil, while the Midland, Mich., plant makes naphthas used in manufacturing fire-proofings, plastics and rubber solvents. The Smiths Bluff plant is tied into a feed supply pipeline with four other companies, furnishing "B-B" cut to the Port Neches butadiene plant, as its contribution to the synthetic rubber industry. With the other oil companies, Pure helped supply technical men and information for the design and construction of the Port Neches plant. Some of the technical men remain to help supervise operations.

Supervising generally the technical phases in Pure's refinery division is C. M. Ridgway, just returned after more than a year with PAW as chief of the refining division's economic section. Mr. Ridgway graduated in chemical engineering from the University of Michigan in 1923, spent 9 years acquiring a variety of experience in the steel industry, petroleum refinery construction, and refining. He came with Pure in 1932 and served as assistant superintendent of both the Heath, O., and Muskogee, Okla., refineries before becoming superintendent of the Midland, Mich., plant. By 1935 he was stationed in Chicago as a member of Pure's Refinery Control Board, remaining until he went to PAW in December, 1942. While with PAW, much of his time was taken up by his special connection with the aviation gasoline program.

C. M. Ridgway

J. B. Rogerson

W. M. Carney

W. M. Wilson

O. H. Rothe

Lion Oil Refining Butadiene Plant

THE production of butadiene at the El Dorado, Ark., refinery of Lion Oil Refining Co. is under the direction of J. B. Rogerson, refinery superintendent. Associated with him in the operation and maintenance of the butadiene plant are W. M. Carney, chief chemist and assistant refinery superintendent; W. M. Wilson, process superintendent; and O. H. Rothe, chief engineer. The butadiene plant, classified as a "quickie", went into production Oct. 1, 1943.

Born at Smackover, Ark., Mr. Rogerson received his technical training at the University of Arkansas, graduating in mechanical engineering in 1922. He joined the staff of Lion Oil in 1926 and was successively assistant chief engineer, maintenance superintendent, and chief engineer before becoming refinery superintendent in 1932.

Mr. Carney, born in Rudy, Ark., attended the University of Arkansas and the University of Oklahoma, coming to Lion Oil Refining Co. in 1925. He has been chief chemist since 1928.

Mr. Wilson was born in Caney, Kan. and received his technical education at the University of Tulsa, joining the Lion staff in 1933. He has successively held positions in the laboratory, operating department, and engineering department before being made process superintendent in 1940.

Mr. Rothe, born in East St. Louis, attended the University of Illinois where he received his degree in mechanical engineering in 1930. Joining the engineering staff of Lion Oil in 1933, he was later engineering assistant to the vice president in charge of manufacturing and became chief engineer in 1940.

Wartime Plant Security Program Wins Civilian Defense Award

Among 28 plants given awards by the national Office of Civilian Defense for outstanding wartime plant protection programs is the Norco refinery of Shell Oil Co. Inc. At the request of National Petroleum News, Chief Engineer Deal of the Norco plant has described the organization of the work, which included special features because of the location of the plant at a distance from any large settled community.

While the complete defense program is not now considered necessary, the skeleton organization is being scrupulously maintained and the complete program could be quickly made effective in the event of any emergency.

*By D. R. Deal**

EARLY in 1941 it became evident that steps should be taken to protect Shell's refinery at Norco, La., and the village of Norco which adjoins it. Accordingly, preliminary steps were taken and 75 acres of underbrush in the outlying portion of the property were cut, the refinery was enclosed by a cyclone fence with an overhanging barbed wire top and fire-fighting facilities were improved. Also each employe was issued a new type of identification badge which incorporated his photograph, fingerprint, signature, and a symbol designating his department.

After Pearl Harbor and America's entry into the war, it became necessary to provide additional protection facilities to guard against possible air attack and to minimize the damage to plant and personnel in the event of air attack or sabotage. Refinery personnel was organized into several groups, and a specific portion of Norco's protection problem was assigned to each. A coordinator was appointed to act as go-between between the plant management and the protection organization over which he was given direct supervision.

Units in the protection organization were created to handle medical and first aid treatment; fire fighting; police activities; gas and decontamination; operations; stores and supplies; information; bomb reconnaissance; utilities, alarms and communications; protective construction; blackout facilities and wardens; maintenance and demolition; and transportation. These last 5 units were placed under the supervision of the Engineering department. See accompanying chart in Fig. 1.

Within a very short time, air raid warning signals had been installed; field, tower and yard light switches had been well marked and grouped together to enable an operator to extinguish them quickly. The necessary operating lights were shielded; pump and control houses were fitted with blackout curtains and light socks; and burners were shielded. A corps of wardens was organized to patrol and criticize the effectiveness of blackout facilities while the refinery operated at normal capacity during test raid conditions. The local Boy Scout troop served as wardens for the 73 residences on the plant.

Demolition Units Formed

Demolition and transportation units were formed from the regular maintenance and construction forces, while a small staff was arranged to keep the plant storehouse ready for issuing repair materials. In the office, the plant technologists formed an information unit to familiarize the community with the signals, the possible effects of air raids, and precautions which should be taken in the home. Plant engineers were given the task of laying out possible air raid shelters, although none were actually constructed.

The plant utility engineer undertook to provide emergency utilities in case of raid damage to normal facilities and to maintain communications under raid conditions. Auxiliary generators were installed to provide emergency lights in the plant hospital and power for the telephone system. Laboratory employes were trained in gas and gas decontamination work.

The number of plant guards was increased, armed and given special training by a military officer, and sworn in as auxiliary military police. A continuous auto and bicycle patrol was established throughout the refinery, and a special signal was provided for quickly contacting these patrols. The gate guards inspect every visitor's identification and

*Chief Engineer, Shell Oil Co., Inc., refinery, Norco, La.

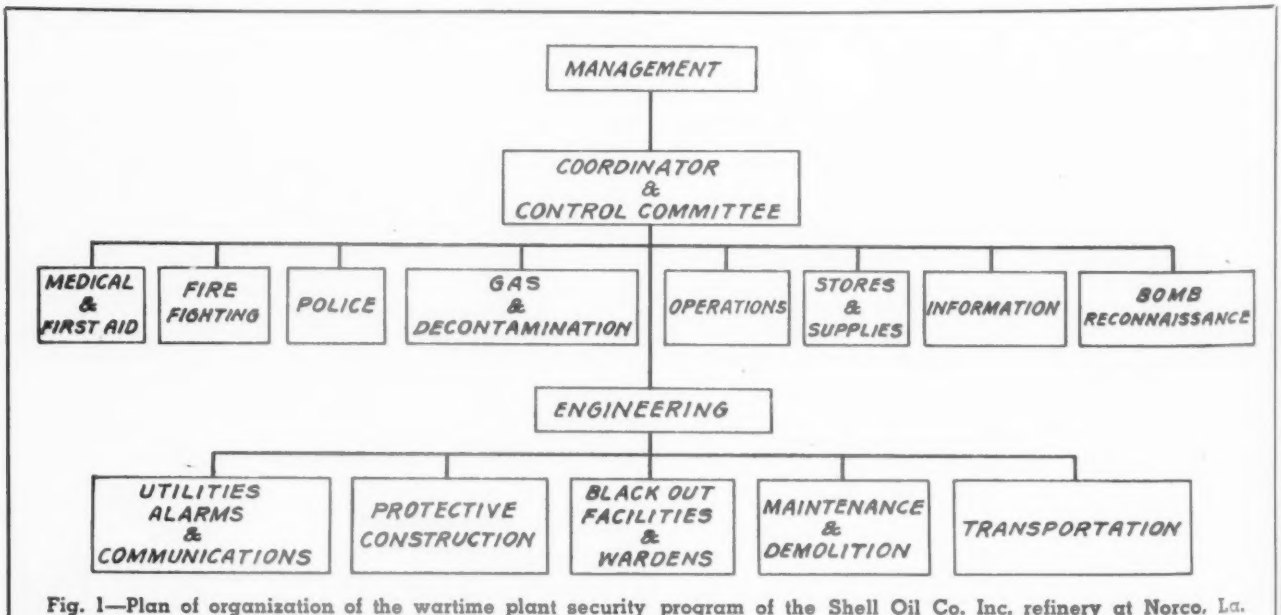


Fig. 1—Plan of organization of the wartime plant security program of the Shell Oil Co. Inc. refinery at Norco, La.

each incoming and outgoing vehicle.

Numerous employes and many of their families volunteered for instruction in first aid work. In addition to the regular plant hospital, 4 emergency first aid stations were set up to operate under blackout conditions, manned by employes holding first aid certificates. Cots, stretchers, first aid kits, splints, etc., were provided for each location. The plant hospital was staffed by the company doctor and first aid workers. All first aid training was given by volunteer instructors, usually employes or members of their families.

Normal practice has been for the refinery fire marshal to constantly instruct and drill plant personnel in fire-fighting methods, the use of equipment, and location of water valves. It is his duty to have enough men on each shift to insure adequately trained fire teams being on hand at any time.

The security program required that greatly increased numbers of employes be given this general training and that all of the fire teams be given special training in combating the fires likely to be encountered as a result of air raids or sabotage. General information for fire protection in the home was passed out to all employes. Regular fire equipment was supplemented by piles of sand bags, buckets, stirrup pumps, shovels, and axes, placed at convenient locations throughout the plant and residential area.

A special committee of key operators for operation-during-blackout was formed to quickly make general shutdown adjustments in event of extensive damage from air raid or sabotage.

One employe was given special training by the U. S. Army in bomb reconnaissance to aid in locating and identifying any unexploded bombs.

Trial blackout drills were held from time to time to allow all employes to become familiar with operation under emergency conditions. Special shaded lenses were provided for converting standard flash lights into blackout lights.

Issued Arm Bands

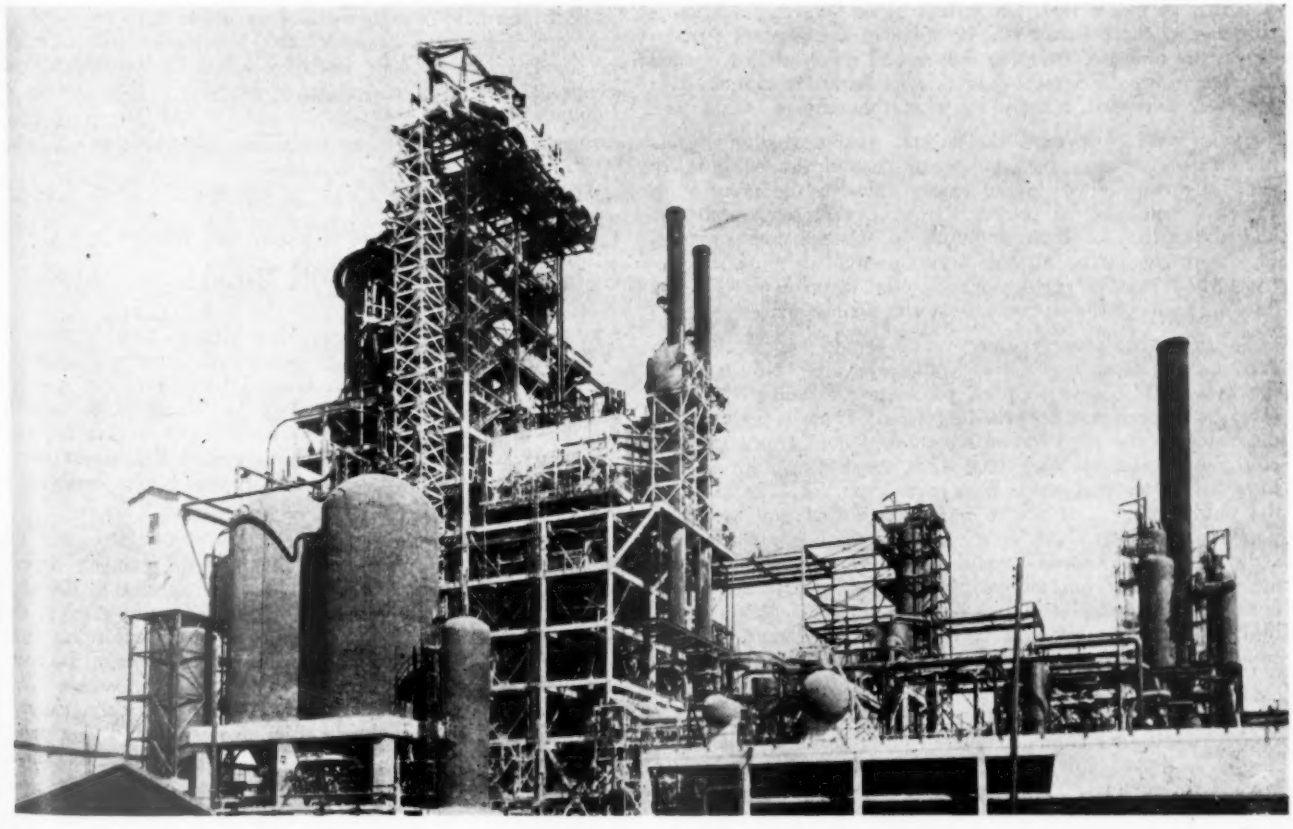
All members of the plant defense organization were enrolled as volunteers in the Citizens Defense Corps and were issued OCD arm bands corresponding to their duties. This enabled them to travel to the plant after the sounding of alarm when the Auxiliary Police outside the plant were stopping all other traffic.

Since the Norco Refinery is located in a small community the plant alarms and lights were the only source of air raid warning for the entire vicinity. Special telephone communications were established to receive raid information direct from the control center in New Orleans, 20 miles away. This information was then relayed to the Civilian Defense units in this portion of the parish.

The Refinery Defense Organization has been of great help in setting an example for the community as well as in giving material assistance. The efforts of this organization were responsible for Norco's winning the National Security Award of the U. S. Office of Civilian Defense, an award which was presented with impressive ceremonies to the men and women of Norco on March 17.

Although the present trend of the war makes a defense organization seem less necessary, great effort is being exerted to maintain the same standard of efficiency in all guarding and fire-fighting units and to maintain a skeleton organization in all other units which can be quickly built up to full effectiveness if the occasion should arise.

New Fluid Catalyst Cracking Unit at Texas City



Seven products are recovered from the fluid catalyst cracking unit of the Pan American Refining Corp. at its Texas City plant. Four are returned to the refinery for inclusion in other than 100-octane gasoline. One of the streams can be blended directly into 100-octane gasoline. The butane-butylene stream before going to the alkylation unit is piped to a synthetic rubber plant in Houston 30 miles away, where the butylene is removed and the residual butanes returned to Texas City. The pentane-pentylene stream from the cracking unit goes to the alkylation plant

WIDENING HORIZONS

Views on Personnel, Management and Economic as Well as Technological Developments in Petroleum Refining and Natural Gas Processing: Comment from Readers Is Invited

Modern Industry Will Provide Many New Uses for Natural Gasoline Products

THE NATURAL GASOLINE manufacturers have been so modest about their contribution to the oil industry's wartime program that comparatively few people know of the expansion that has taken place since 1940 in this branch of the oil industry. Pertinent data, however, was presented at the recent meeting of the Natural Gasoline Assn. of America, in Dallas.

Prior to the war average daily production of natural gasoline and allied hydrocarbons was about 140,000 b/d, James E. Pew, Director of the Natural Gas and Natural Gasoline Division of PAW, told the meeting. During 1940, production increased to a daily average, for the year, of 153,000 barrels. By 1943 production had increased to 242,000 barrels. By the end of 1944, said Director Pew, plants now under construction and those already authorized will raise the industry's output to 320,000 barrels, 129% above the prewar level.

While this alone is an outstanding achievement, it is made more impressive by the fact the natural gasoline industry financed this plant expansion program entirely with its own funds. "Not one penny of Jesse Jones' defense plant money was even asked for," said Mr. Pew. This branch of the industry has indeed gone a long way from the "casinghead" plants of the early 20s. They made a single product to improve the volatility of motor fuel, which had to be "weathered" before shipping so there would still be some of the product remaining in the tank car after the refiner had received and opened it. The prices the natural gasoline manufacturers of those days received depended entirely on what the refiners would pay.

Since those early days the natural gasoline manufacturers have made themselves an important part of the oil industry and have contributed to the conservation of the natural resource it handles. At present, however, their aggregate size and the nature of their activities in the wartime program give them concern as to their future position in the oil industry. Their postwar position was painted in none too cheerful hues in some of the discussions at the Dallas meeting.

To an outside observer, however, it would appear that the size of the natural gasoline and allied recycling industry, and the fact that it now supplies products for widely different uses, are a good guarantee for its future. There is wide public discussion on the need for conservation of our natural gas and petroleum resources, including what we can use for substitutes for motor fuel made from petroleum. In this state of the public mind it is not to be assumed that any group of plant operators who can conserve more than 300,000 barrels a day of what otherwise would be lost can write themselves out of the petroleum industry, even if they so desired. If domestic crude supplies are to be short for some refiners, natural gasolines can be used to build up the volume of their supplies of motor fuel before we consider substitutes.

However, natural gasoline manufacturers, today, have many other outlets for their products than for motor fuel blending. The marketing of liquefied petroleum gases has become a sizable business, now running over 50,000 barrels a day, more than ten times its volume of only ten years ago. Utilization of LPG products has expanded during the war and will increase further in future peace times, as new uses are found for these convenient sources of heat and power. G. G. Oberfell, of Phillips Petroleum Co., an authority on this phase of the oil industry, recently gave some examples of how industry is finding these products of great value in varied operations. Propane is used in metal cutting to speed the fabrication of ships. The use of LPG in glass making and in many heat treating operations has grown at a rapid rate.

The natural gasoline manufacturer's products, aside from blending with motor fuel and as liquefied gas, are used for aviation gasoline base stock, for materials for making butadiene for synthetic rubber, styrene, explosives and other essential chemicals. Products of the degree of purity that can now be achieved in commercial plants are also finding a place among industrial solvents, the general use of which is increasing rapidly.

Many years ago, in the days before the Chautauqua circuits, a public lecturer named Russell H. Conwell was in demand for an address which had enough truth and inspiration in it to live on after its author and is widely read today. It was called "Acres of Diamonds". It was the story of a Persian who lost his health and riches in the search for diamond deposits to make him even more wealthy. The land he originally owned later became the location of the richest diamond mine in the world, goes the story. This same theme could be tried in the study for new markets for oil products in these days of complicated industrial processes, coupled with the ability of the oil companies to manufacture products of a high degree of purity to meet very precise specifications.

It would be safe to wager that many refiners and natural gasoline manufacturers could find in their own marketing areas instances where some product they are making or could make would have a higher utilization value than the products now supplied for the same industrial application. These might be small volume markets, but they would have a high degree of profit when supplementing a company's manufacture of standard products.

Chemists Offer a Preview of Research Being done in Catalytic Cracking

WHILE it has been known that a great deal of study is going on into the nature of catalytic reactions involving petroleum hydrocarbons, it remained for the recent meeting of the American Chemical Society in Cleveland to provide the first detailed reports on this work. The studies reported throw considerable light on the nature of the several complete side reactions that occur in the presence of catalysts of the type used in petroleum refining.

Valuable data were reported by one investigator for the Universal Oil Products Co. on the part the catalyst deposit plays in the reaction known as hydrogen transfer in the conversion of olefins into paraffins. Instead of the catalyst deposit being regarded as a necessary nuisance resulting from side reactions, it can be formed as an integral part of the reaction and the products associated with its formation are often desirable, stated this investigator. Where hydrogen fluoride is the catalyst, seven principal reactions were listed in a paper by another group of investigators from the same organization.

Investigations of this type when fully developed will be of great value in providing material for the more efficient design of units for catalytic refining. It is to be hoped that more of the research work being done in the use of catalysts can be promptly reported because of its value to applied refining technology.

Technical Section, NATIONAL PETROLEUM NEWS

Published Every Month by

The National Petroleum Publishing Company

Publication Office, 1213 West Third Street, Cleveland 13, Ohio, U. S. A.

V. B. Guthrie, Editor, Technical Section • D. P. Thornton, Jr., Assistant Editor

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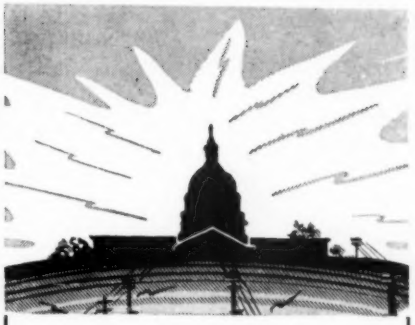

NEWS from Washington on ARABIAN OIL

The chief topic for discussion these days seems to be the Trans-Arabian pipeline project . . . From all appearances there will be many stormy sessions of pros and cons on this famous foreign oil deal, which seems now to be raising a problem of international political danger.

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